COUNTWAY LIBRARY
HC 1AAT -

ACUTE POLIOMYELITIS

(INFANTILE PARALYSIS)

B W Paddock.

from

George Draper

Aug 1920

ACUTE POLIOMYELITIS

DRAPER

ACUTE POLIOMYELITIS

BY

GEORGE DRAPER, M.D.

ASSOCIATE IN MEDICINE COLLEGE OF PHYSICIANS AND SURGEONS, COLUMBIA UNIVERSITY;
ASSOCIATE ATTENDING PHYSICIAN PRESBYTERIAN HOSPITAL
NEW YORK CITY

WITH A FOREWORD BY

SIMON FLEXNER

BOSTON MEDICAL LIBRARY
IN THE
FRANCIS A. COUNTWAY
LIBRARY OF MEDICINE

WITH NINETEEN ILLUSTRATIONS

PHILADELPHIA
P. BLAKISTON'S SON & CO.
1012 WALNUT STREET

COPYRIGHT, 1917, BY P. BLAKISTON'S SON & CO.

THE MAPLE PRESS YORK PA

FOREWORD

The epidemic of poliomyelitis which swept over the Eastern United States during the past summer and autumn achieved a new record. The number of cases exceeded that of any previous epidemic reported and the mortality approached the maximum recorded.

Hence it becomes very desirable to profit by the experience gained in the daily study at the hospital and in the home, at the bedside and in the laboratory, under the exceptional conditions of the epidemic, in order that we may be prepared to meet the future with greater knowledge and confidence.

Dr. Draper's book is a timely contribution to this purpose; but it is much more than that. He brought to his task a considerable previous experience in the clinical and experimental study of poliomyelitis. During the two years in which cases of the disease were taken into the Rockefeller Hospital, he was one of the small group in charge of that special service. The results of the clinical and laboratory studies carried out there have been assembled into a monograph issued by the Rockefeller Institute for Medical Research. Of this monograph, Dr. Draper is part author.

This particular experience is reflected in the book which he has now written, for in it he has combined clinical and experimental data in a way peculiarly illuminating and valuable at the present time. But in treating the subject in this inclusive manner, the objective clinical character of the book has not been lost. Indeed, it may be taken as a practical guide to the diagnosis, care, and specific treatment of epidemic poliomyelitis.

The appearance of the book is opportune. Just what the coming summer and autumn may have in store cannot be predicted, but it is altogether too much to hope that the epi-

demic will not prevail in some degree in this country. A great need has been felt in the past for an experiential book that is up to date. This need is happily now supplied.

SIMON FLEXNER.

ROCKEFELLER INSTITUTE FOR
MEDICAL RESEARCH

PREFACE

The problem of poliomyelitis with which this book attempts to deal is not a new one and has been much discussed in the literature of many lands. Until 1907 this country had felt but little the terror aroused by visitations of acute epidemic poliomyelitis, and consequently the public and the medical profession at large have been unaware of the serious menace that the disease presents.

The reports from other countries bearing on the subject have not reached the rank and file of the medical profession so as to develop in their minds a conception of this protean and remarkable disease as a clinical entity. This has been largely due to the facts that what has been written about poliomyelitis has appeared in a variety of languages and also in fragmentary manner. From one author has come remarks on the pathology, from another description of the clinical course, and from others discussion of epidemiological and experimental studies. Furthermore these various contributions have not appeared in any particular relationship to one another. This is especially true of experimental and clinical studies. Even the various monographs which have been published during the past five or six years deal with one phase of the problem or another rather more especially than with the subject as a whole.

A further obstacle to the earlier full appreciation of the nature of the disease has been its two incorrect and unfortunate names: "Poliomyelitis" (from πολιός, gray, and μυελός, marrow) has served to focus the attention of observers upon those symptoms which were naturally associated with disturbances of the gray matter of the spinal cord, namely the paralysis. The second name "infantile paralysis" is a dual misnomer, for the disease is no more limited to infants than it is to paralytic symptoms. It is curious, too, that notwithstanding the gradual realization, resulting from many severe epidemics, that the malady was of

infectious nature, clinicians and the public have been loath to give up the fixed conception that paralysis is the beginning and end of the story.

The purpose of the book therefore is to present as completely as possible, within reasonable space, the more recent conception of this remarkable disease by correlating as far as possible all the facts at present available.

It is designed to develop the idea that acute poliomyelitis is a general infectious disease, in the course of which paralysis is but an accidental and incidental occurrence.

The observations upon which much of this book is based are drawn from the epidemic of last summer. For certain parts of the statistical material I am indebted to the Commissioners of the New York City Health Department, and of the New York State Department of Health.

There has been no attempt made to give a complete bibliography nor to refer by name to all the individual contributors to the subject.

[1]The Monograph and other publications of the Rockefeller Institute have been drawn on liberally for facts and statistics and in some instances actual passages of the text have been incorporated in the present work.

The author desires to express his sincere appreciation of the advice and encouragement given by Dr. Simon Flexner and Dr. H. L. Amoss.

[1]Reference is made so frequently to the Monograph of the Rockefeller Institute that throughout the book, for convenience, it will be spoken of simply as the Monograph.

CONTENTS

CHAPTER I

History

PAGE

First mentions—Early and subsequent epidemics—Development of clinical knowledge—Development of experimental knowledge.... 1

CHAPTER II

Etiology..... 6

CHAPTER III

Epidemiology

Concentric or radial method of spread—Isolated cases—Contact groups—Immunity of areas previously involved—Insects and lower animals..... 13

CHAPTER IV

Experimental Disease

The virus—Technique of transmission to monkeys—Bacteriology—Immunity—Neutralization reaction..... 23

CHAPTER V

Pathology

General visceral lesions—Ganglia—Nervous tissue lesions—Meningeal invasion—Perivascular infiltration—Neurophages..... 30

CHAPTER VI

Types

Classification by paralysis—Classification by general symptoms..... 38

CHAPTER VII

Symptoms

Prodromata—Onset—Course—Pain—Spine sign—Reflexes—Psychic, Mucous membranes, Digestive tract..... 62

CHAPTER VIII

Symptoms

Page

Clinical pathology—Blood—Spinal fluid..... 70

CHAPTER IX

Symptoms

Paralysis—Time of appearance—Degrees—Respiratory—Delayed form..... 75

CHAPTER X

Prognosis

As to paralysis—As to life—As to recovery from existing paralysis.... 81

CHAPTER XI

Treatment

Early hours—After Paralysis—Prophylaxis..... 85

Index..... 147

ACUTE POLIOMYELITIS

CHAPTER I

HISTORY

The story of the development of our knowledge of poliomyelitis does not follow a single path continuously from the earliest beginnings to the present time, but rather represents the converging of several lines of study. Three distinct avenues of investigation present themselves, the clinical, the pathological, and the experimental. Each of these has a very definite history and the contributions to each path have been made by various observers quite distinct from those working in other paths. The first observation of the clinical phase of the disease was probably made by Underwood[1] in 1774. His description is very meager and only suggests that he recognized the fact that children might suddenly become paralyzed after a brief illness. The next mention of the disease in the literature is that made by the English physician Badham[2] in 1835. His description is much more definite and has to do with a small group of children in a circumscribed neighborhood. There can be very little doubt that Badham described acute poliomyelitis. But the first systematic study of the clinical picture of this malady was made by Jacob Von Heine[3] in 1840 in the village of Kolmar in Germany. Heine was an orthopedic surgeon and saw a great many cases of paralysis in children, and became interested in the subject. His investigations led him to investigate the stage of the disease not usually seen by the orthopedic surgeon and he was the first to realize that this peculiar paralytic visitation was always preceded by an acute febrile period. Heine's description of this phase of the disease demonstrates that he appreciated that there was a febrile reaction which might be so mild as not to arouse any anxiety in the minds of the parents and pointed out indeed the great

contrast between their feelings during the acute stage and later when they suddenly discovered the paralyzed leg on the morning following the acute symptoms. To Heine undoubtedly belongs the credit for first having drawn attention to this disease as being a clinical entity and also for having given the first complete description of it.

Following Heine's work, the literature is barren of any discussion of the disease until 1884 when Strumpell[4] in Vienna described an encephalitic type which he believed to be similar to the true poliomyelitis anterior of children as described by Heine. He also drew attention to the fact that there were certain forms of acute neuritis in children which belonged also in this same group; thus, he brought together the neuritic type, the poliomyelitic type and the encephalitic type and supposed that they were all one and the same disease. He also threw out the suggestion which was the first of its kind, that the disease was probably of an infectious nature.

The next important step in the clinical study was that of Medin[5] who published in 1889 a description of the large epidemic in Sweden. In Medin's work appears for the first time an excellent description of the acute stage of the disease, and we are first given the impression that we have to do here not alone with the paralytic affliction but also with an acute general infection.

Then again there follows a long period of silence on the subject until Wickman[6] in 1905, studying the vast epidemic in Sweden, developed what may well be considered the modern conception of the disease. His pathological, clinical and epidemiological studies form a classical contribution to the growth of our knowledge of acute poliomyelitis, and established the disease finally as a clinical entity. Wickman was the first to point out the so-called abortive type, a name which is undesirable, and which has remained attached to those cases which never develop paralysis. His epidemiological studies also gave strong support to the view that the disease was transmitted by contact.

Since Wickman there have been numerous contributions to the clinical study of the disease from various countries. Among

others, extensive contributions have been made by Müller,[7] Zappert,[8] and from the Hospital of the Rockefeller Institute.

The history of the development of knowledge of the pathology of this disease probably begins with the description by the French in 1865. At that time Provost and Vulpian[9] found an atrophy of the anterior horns and ganglion cells in old cases of poliomyelitis dying from other causes. This finding was corroborated in 1870 by Charcot and Joffroy[10] who also went further and developed the hypothesis that the cells of the anterior horn were the trophic centers of nerve and muscle, and that they were the point of origin of the pathological process in poliomyelitis. In 1871 Roger and Damesceno[11] went still further and described in the pathological process of much earlier cases than had been seen by previous observers, the interstitial and perivascular lesions. This observation seems to be the very earliest indication of the more modern conception of the pathological process in infantile paralysis. After the work of Roger and Damesceno the next expression on the subject of the pathology was made by Rissler[12] in 1888. He held out for the theory that the initial damage was directly upon the ganglion cells of the anterior horns. His pathological material was largely from more acute cases than had previously been examined. Nothing further then appeared until the work of Wickman[13] in 1905 when he published his extensive pathological studies from the acute material of the large Swedish epidemic. He demonstrated by the most painstaking and extensive investigation the infiltration processes suggested by Rogers and Damesceno and also showed very clearly the intimate association of the blood vessels with the whole process.

In 1907 Strauss[14] pointed out that cases examined shortly after death in the acute stage of the disease revealed general swelling of the lymphatic apparatus throughout the body. Similar observations were mentioned in the same year by Harbitz and Scheel,[15] and again by Wickman in 1911.[16]

In 1912 Flexner, Peabody and Draper[16a] noted that, aside from the lesions in the central nervous system, there were generally distributed lesions through the parenchymatous organs and lymphatic structure of the body. This observation

agreed well with the growing belief that the disease was not limited to the central nervous system but was a general systemic infection.

The third path in the growing knowledge of the disease is that of experimentation. The whole history of this phase of the investigation is of most recent date. It may be said practically to begin with the transmission of the disease to monkeys. Previous to this there had been some attempt to work out a bacteriology, but without success.

The first successful transfer of this disease to monkeys was accomplished by Landsteiner and Popper[17] in Vienna in 1909. But these observers failed to advance the study of the experimental disease further by reason of their inability to propagate the infection through a series of monkeys. They had used only the intraperitoneal route of injection. Within a few months, however, Flexner and Lewis[18] succeeded by means of intracerebral inoculations, in carrying on the disease indefinitely from monkey to monkey. In rapid succession came confirmation of this method by Landsteiner and Levaditi,[19] Leiner and v. Wiesner[20] and others. By this means it became possible to keep the virus of poliomyelitis growing indefinitely and so to study its nature, and its behavior toward various physical and chemical agents. Since then, contributions to the literature of experimental poliomyelitis have been numerous, and there have been developments in all branches of the laboratory study of the disease. In 1909, independently of each other, Landsteiner and Levaditi,[21] and Flexner and Lewis[22] showed the virus to be filterable.

Finally, in 1914, Flexner and Noguchi[23] published the report of experiments on the cultivation and isolation of an organism which seemed to be associated always with the disease. Up to the present time this has neither been controverted nor broadly confirmed. The most recent observations, however, tend to confirm the observation that the organism of Flexner and Noguchi is the cause of poliomyelitis.

A review of the history of this disease is interesting because it shows that while the paralysis had always been the central thought about which all discussion centered, nevertheless in

almost every description of the disease from the time of Badham in 1835, there appeared also remarks which indicated that the observer had recognized the presence of certain symptoms characteristic of acute infections. From the very first all have agreed that there was an acute stage in poliomyelitis. Usually this stage was looked upon as representing the prodromal period which, with varying severity, ushered in the paralytic attack. The demonstration by Wickman of the "abortive" or non-paralyzed forms went far to break down this view and to initiate our present conception of an acute systemic infectious disease in which paralysis may or may not occur.

CHAPTER II

ETIOLOGY

The discussion of the etiology of poliomyelitis will be considered here under two main heads, first that of susceptibility and, second that of the active forces of the disease.

Susceptibility.—During the last few years there have been many observations in the literature of infectious diseases suggesting the possibility that certain types of individuals possess special susceptibility toward certain diseases. These various suggestions are rather vague, but they all indicate that by a careful study of the type of individual, both physiologically and anatomically, there may be some things which we have not heretofore recognized that determine the greater or less susceptibility of an individual for one or another disease. Everyone who has worked in poliomyelitis wards has been impressed with the great number of large, healthy, well-nourished children afflicted with the disease. Any layman who enters such wards remarks invariably upon the strong and healthy appearance of the patients. In other words, it is common experience that poliomyelitis patients are large for their age, well nourished, plump, and with faces of rounded form. With the same idea in view of determining types which are susceptible, many observations have been recorded during the past year on the question of whether brunettes or blonds are more susceptible, whether boys or girls are more susceptible, and whether there is a difference in the susceptibility of various races. None of these series of observations has yielded results of convincing nature. Statistics show in the recent cases in New York that boys were 55.8 per cent., girls 43.7 per cent. These figures agree fairly well with those reported from other epidemics. Thus in Massachusetts[24] in 1911 the statistics showed that males were 56 per cent. and females 44 per cent. of the total. Caverly reports[25] males 57—60 per cent. and females 43—40 per cent.

TABLE I.—FROM REPORT OF MAYOR'S SPECIAL COMMITTEE[1]

	City
Native (born in U. S. A.)	3825
Italian	1348
Russian	1287
Irish	644
Austrian	479
German	479
Polish	224
Norwegian	101
English	181
Hungarian	103
Roumanian	59
Scotch	46
Swedish	75
Lithuanian	14
West Indian	20
French	17
Danish	14
Canadian	20
Bohemian	18
Finn	26
Syrian	9
Greek	17
Swiss	14
Spanish	12
Dutch	5
Turkish	10
Cuban	6
Slavonian	2
Belgian	2
Porto Rican	1
Portuguese	1
Mexican	1
African	1
South American	1
Indian	1
Armenian	2
Ukarainian	1
Japanese	2
	9005

[1] Supplied by the kindness of the Commissioner of Health, New York City.

Racial groups in the city showed various susceptibility. The foregoing table taken from the report of the Mayor's Special Committee[26] indicates the distribution of cases among many nationalities. The negroes seemed to be less affected than the whites, but the difference in number stricken per capita of the blacks and whites is not great enough to base absolute statement of relative immunity upon them. Besides there enters the factor of less active social intercourse between the two races so that an epidemic disease starting among the whites might well not invade the black race extensively. This same group protection might be a reason for the apparent immunity of those peoples whose language made intercourse with Americans difficult.

The type of child which seems to be most susceptible to the disease is the large, well-grown, plump individual who has certain definite characteristics of face and jaws, is broad browed, and broad and round of face. The teeth are particularly interesting. It was noted that in 50 to 60 per cent. of all the cases in the hospital at Locust Valley, the central incisor teeth of the upper jaw were separated by a cleft of varying width. The wide spaced dentition has been a striking feature and frequently involves all the single teeth of both jaws, so that each tooth stands entirely free.

For many years the close association of this disease with the process of difficult dentition was thought to have some etiological significance. While no positive proof can be advanced that there is a relationship here, yet it is worthy of note that so many children with poliomyelitis present abnormal dentition.

Among the adolescents and young adults who acquired poliomyelitis and in whom the disease seemed always to be most severe and indeed usually fatal, the type differed from that just described. Instead of the very large, well-nourished individuals with widely spaced teeth, there appeared a more delicately made type. Of the six or eight fatal cases in young adults seen by the writer, the similarity of appearance of the individuals was so striking that all might have been of one family. All were brunettes, with very delicate dark skins and

high coloring of cheeks and lips. Often small deeply pigmented moles were present on face or neck. There was in every case a

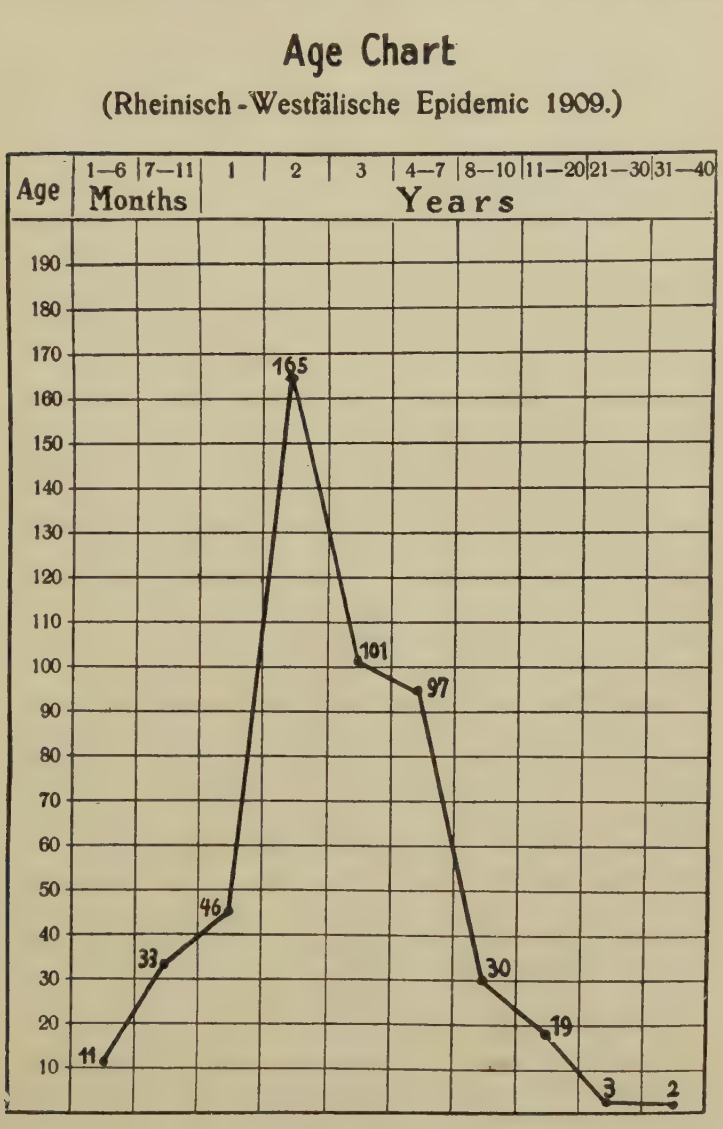

FIG. 1.

definite though finely chisled maxillary prognathism and instead of dental separations a tendency to crowding of the

teeth. This type was so definitely and so frequently associated with the severe form of the disease that we have come to attach grave prognostic significance to it. In this connection, it is interesting to note that a surprising number of the fathers of children ill with poliomyelitis presented striking anthropological markings. Thus one was a definite acromegalic, while two others were clearly Froelich types, dark haired, fat faces and bodies, narrow shoulders, broad hips, and knock knees. In three others maxillary prognathism was marked and although the body stature was small the hands were very large and broad, and there was great physical strength. A seventh father had widely separated upper incisor teeth and was a tall, big boned individual. Four of the mothers in this group had moderate or marked exophthalmos and were high strung, intensely nervous women. In another instance, the mother of two desperately ill cases had an unusual degree of maxillary prognathism.

Whether or not these facts have a bearing on the question of susceptibility is still problematical. The cited examples, however, are merely a few of the very many similar observations made throughout the summer by the diagnosticians of the New York State Department of Health on Long Island. It is interesting too, to record the numerous instances of two, three, four and five cases in families with such parental types, suggesting possibly a true family susceptibility.

The ages chiefly affected by the disease can best be shown on a chart. It is obvious that the second year is the most constantly affected.

The number of cases reported in adults was considerable. Thus the report of the Special Committe indicates that out of 5496 cases the following were above 10 years:

Ages	No. of cases
10 to 15	94
15 to 20	32
20 to 30	40
30 to 40	25
40 to 50	7

Occupation seems to have had no bearing at all upon the sus-

ceptibility. As regards environment, there seems to be little to mention. In the crowded tenement quarters the disease raged, and also in the sparsely settled country districts. Furthermore, there seems to be no relationship to the degree of social evolution of the people involved. Cases appeared in the humblest and most squalid dwellings, as well as in the most elaborate mansions.

The recent demonstration by Amoss and Taylor[27] of neutralizing substances in the nasal secretions of certain human beings is of great interest. Apparently several facts have been established by their work. In the first place, although the number of individuals observed is not great, it appears that the nasal secretions of children may possess the neutralizing substances less regularly than adults. These authors showed that nasal secretions from a child on the fourth day of an attack of poliomyelitis had no neutralizing powers. But on the fourteenth day afterward, neutralizing bodies made their appearance. This seems to be a direct relationship to the development of neutralizing bodies in the blood which have been shown to be present on the sixth day. It was further demonstrated in their investigations that an adult whose nasal secretions contained the neutralizing substance in health lost them during an attack of choryza. They returned again at the conclusion of the acute rhinitis.

These observations indicate the possibility, therefore, that some individuals may be susceptible to acute poliomyelitis because of failure of these neutralizing bodies in the nasal secretions. The failure as it were of a first line of defense.

Various bacteria have been described in association with cases of poliomyelitis, but none of the bacteriological findings have been satisfactorily confirmed. Since the demonstration, however, of the virus of poliomyelitis in the emulsions of spinal cords of children dead with the disease in 1909 by Landsteiner and Popper, the advance in knowledge of the infectious agent has been steady and rapid. The natural history of the virus has been worked out very fully in the laboratory. Finally, the organism itself, or an organism, which appears to be constantly associated with the disease and able to reproduce

it in animals fulfilling Koch's laws, was isolated by Flexner and Noguchi in 1914. Up to the present time this organism has been confirmed by several laboratories and there has been no complete disproof of its specificity. Whether or not the polymorphous organism described by Mathers,[28] Rosenow,[29] and others and having affinities with the streptococcus is the same biological entity as that of Flexner and Noguchi is a question which the accumulative weight of scientific observation and experiment will determine. At the present writing adequate proof of a relationship has not been brought.

CHAPTER III

EPIDEMIOLOGY

Wickman first made a careful epidemiological study of poliomyelitis. As a result of his work he concluded that the disease was transmitted by contact of human cases with healthy people. In a series of painstaking observations he showed the undoubted relationship of the village school to the dissemination of the disease. Before this observation attention had been drawn to the tendency of the disease to appear along the main routes of communication. But the immediate methods of transmission were not suggested. At that time the disease was looked upon as "infectious but not contagious." In 1907 Wickman showed that infantile paralysis was spread by transmission from person to person and that the so-called "abortive" forms played a highly important part in its dissemination. Wickman pointed out among other things, that although poliomyelitis occurred largely in the late summer and early fall nevertheless epidemics had occurred more than once in the winter. This is a matter of considerable importance and will be referred to again in the discussion of the question of insect transmission.

By studying in detail small circumscribed settlements Wickman was able to demonstrate that from the village school as a center the disease spread in a radial or concentric manner. Furthermore, he demonstrated satisfactorily that the individuals with the non-paralytic form of the disease were able to transmit it to others who in turn developed paralysis. Finally, Wickman recognized that in some instances a healthy intermediary (possibly carrier) might be the medium of transmission.

These original fundamental concepts of Wickman concerning the epidemiology of poliomyelitis have been supported by observations from every carefully studied epidemic which has occurred since his classical study.

A second series of groups indicating human contact transference of poliomyelitis is that also first pointed out by Wickman dealing especially with more isolated cases not connected with schools. Some excellent examples of this type of group infection have been published by Sheppard.[30] The following two groups from his series illustrate definite instances of direct and indirect contacts:

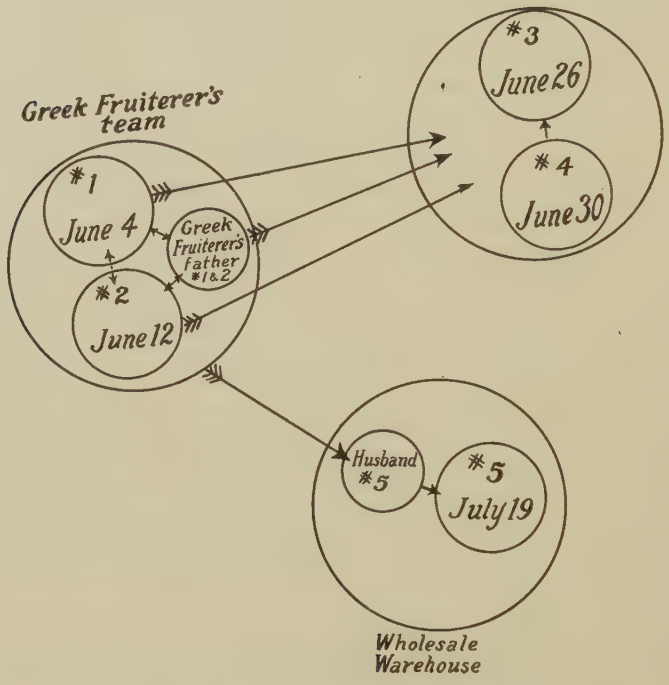

FIG. 2.—(Reproduced from *N. Y. State Journ. of Med.*)

Five cases occurred in this group. Case 1 occurred on the 4th of June; Case 2 on the 12th of June. The father of Cases 1 and 2 is a Greek fruiterer who traveled extensively over the city with his fruit team and most of the time prior to their illness was accompanied by Cases 1 and 2.

Case 3 occurred on the 26th day of June in a family where the father of Cases 1 and 2 delivered fruit, etc., and came into intimate contact with the Greek fruiterer and his children, Cases 1 and 2.

Case 4.—An abortive attack occurred on the 30th of June. This case was also exposed to the Greek fruiterer and his children, and to Case 3 intimately.

Case 5 occurred on July 19th, an adult which terminated fatally. The Greek fruiterer (father of Cases 1 and 2) bought his fruit, etc., at the wholesale warehouse where Case 5 frequently spent much of her time in the office with her husband (the proprietor of the warehouse). The Greek traded exclusively with the proprietor and hence the contact was frequent and intimate and much paper money passed between them. The line of contact for Case 5 was indirect as far as we know.

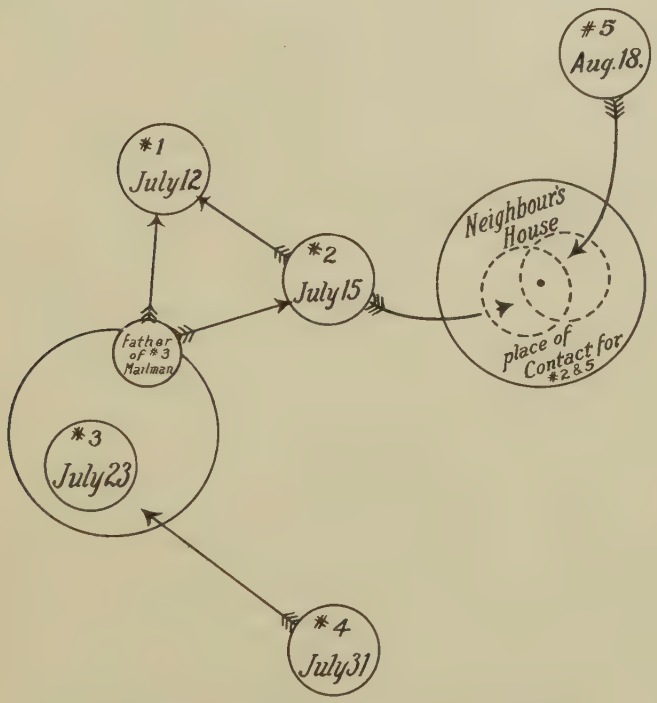

FIG. 3.—(Reproduced from *N. Y. State Journ. of Med.*)

Five cases in this group. Case No. 1 occurred on July 12th and was unrecognized by the attending physician.

Case No. 2 occurred on July 15th and was previously in intimate contact with Case No. 1. This case was also unrecognized at the time. Both, however, were reported to the local authorities as positive cases a month or so after their attacks.

Case No. 3 occurred on July 23d in the family of a letter carrier who delivered mail at the homes of Cases Nos. 1 and 2.

Case No. 4 occurred on July 21st and was in intimate contact, playing with Case No. 3 and visiting at the home.

Case No. 5 occurred on August 18th in a young adult who gave a history of visiting in the house next door to Case No. 2, in which house Case No.

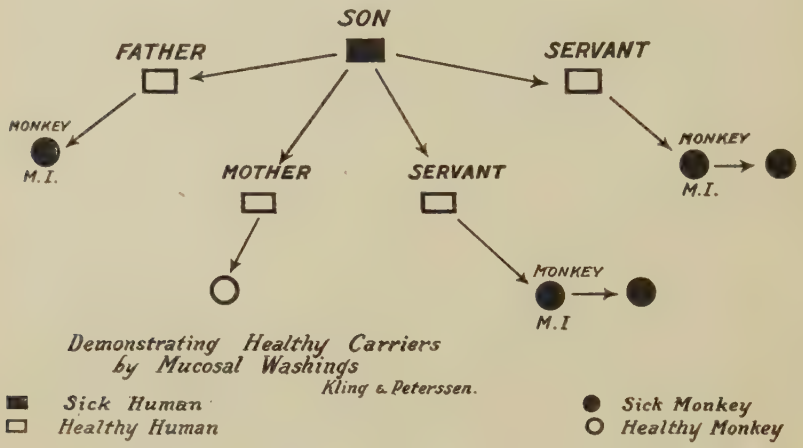

Fig. 4.

2 had free access. This young adult came in contact with Case No. 2 in this neighboring house.

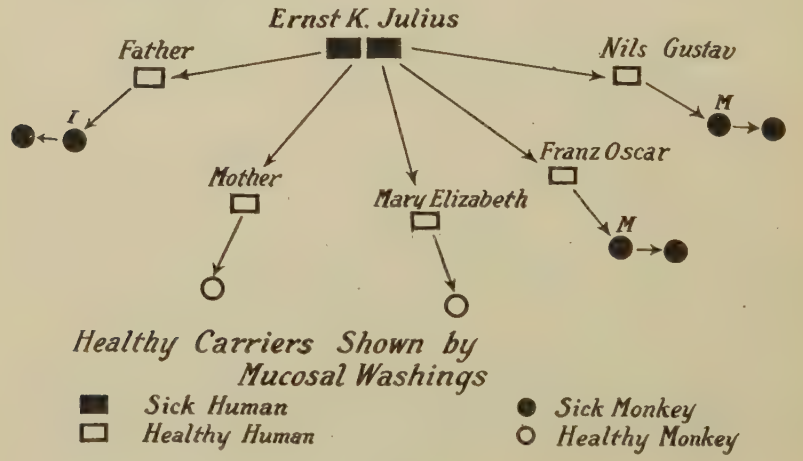

Fig. 5.

Such examples as these lend strong support to the hypothesis that the disease is spread by human contacts. That such dangerous contacts, however, are not limited necessarily to

active cases, but may be produced by healthy intermediaries, is indicated by the example cited. It is worthy of note too, in this connection, that the virus has been demonstrated in the mouth and nose washings of individuals who have been in intimate contact with known cases of poliomyelitis. Flexner, Clark and Frazier[32] report finding the active virus in the nasal and pharyngeal secretions of the parents of a child stricken with the disease. The proof of this observation is complete in the clinical and anatomical findings on the monkeys injected with the parental washings. Both symptoms and pathological changes were typical of acute poliomyelitis. Kling, Pettersson and Wernstedt[33] carried out extensive investigations of this point and the main results of their studies are shown in the following two charts constructed from their protocols.

In the first group (Fig. 4) of the four healthy individuals surrounding the patient, three harbored the virus; in the second group (Fig. 5) three out of five carried the infectious agent. Some doubt still exists as to satisfactoriness of the proof offered by these experiments, for the pathological changes that these authors describe in their monkeys are not altogether typical of acute poliomyelitis. They offer to explain these discrepancies on the ground that in carriers the virus is less virulent.

As there is no convenient way of recognizing these healthy "carriers" their number must remain an uncertain quantity and their control impossible. But there is another large group of cases which undoubtedly play a very important part in the spread of the disease. With the growth of our clinical knowledge of poliomyelitis has come the realization that the majority of cases never display any evidence of central nervous system damage. The great difficulty of recognizing these unparalyzed cases and consequent failure to prevent their free circulation in the community seriously handicaps the accurate study of the links of an epidemic chain.

One of the prominent epidemiological features of poliomyelitis is its seasonal occurrence. Fig. 6 shows clearly that the disease occurs most intensely during the months of July, August and September. This warm weather relationship has been one of the strongest reasons for believing that insects are

responsible for the spread of the malady. But it must be remembered that winter epidemics have been reported from Sweden and Norway. Furthermore, during the past winter,

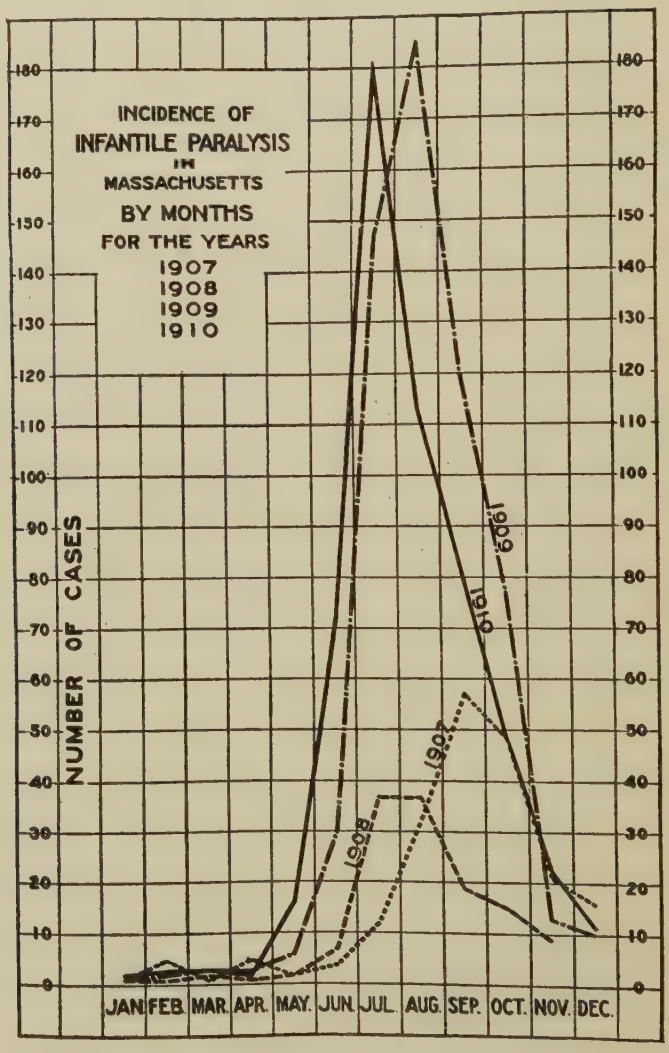

Fig. 6.

in the month of February, a good-sized epidemic occurred in the mountains of West Virginia.

According to the still unpublished report of the Department

of Health of West Virginia,* the first case in this epidemic started at Elkins on August 29th; the second case appeared September 9th and the third case October 10th. The disease took epidemic proportions about December 10th.

The total number of cases reported was 39 paralyzed and 35 non-paralyzed. The epidemic in the neighborhood of Grafton covered a period between December 10th and Feb. 12th. In this there were 22 paralyzed, 6 non-paralyzed and 6 deaths. The first case in Fairmont was on January 6th; the total paralytic cases were 15 and 3 deaths.

Apparently the definite effect upon the spread of the epidemic was accomplished by preventing gatherings of children and interstate travel of children under 16 which was rigorously carried out. Thorough investigations were made of the insects and small animals in the neighborhood as well as studies of the food supply and milk; but nothing of importance was discovered.

It is interesting to know that the mean temperature during the period of December and January was 32°F. Besides this definite epidemic there have been occasional scattered cases in and about New York. One case appearing at Northport, Long Island, in the beginning of March, and which had a fatal termination, was particularly interesting because of the fact that the week before the patient began to be sick he had been in a rough and tumble fight with a child who had had the disease during the epidemic of the summer before. Washings of the nose and throat of this recovered case were injected into a monkey in the hope of demonstrating that it was a carrier, but the monkey failed to develop the disease. This, of course, is not a convincing experiment, because of the wellknown difficulty of producing disease in the monkeys with nasal washings, in any case.

Attention may also be drawn again here to the experiments of Amoss and Taylor on nasal secretion already referred to. They indicate the possibility that carriers may be those individuals whose secretions lack the usual neutralizing bodies.

At the present time the most convincing evidence points strongly to human contact as the means of spread. For in

* This preliminary report is available through the courtesy of Dr. Carrol G. Bull.

addition to the epidemiological studies of Wickman, Sheppard, Kling and Pettersson, Flexner and Frazier, cited above, there remain those extraordinary instances of group immunity during the past epidemic reported by the New York City Department of Health. One of these, the instance of the 30,000 institutional children in New York among whom no case occurred is interesting because of the great numbers involved. All the institutions harboring this large group were under rigid admission and visit quarantine regulations. Each new child was detained two weeks in an observation ward before admission to the general ward, and visitors were excluded altogether from the 1st of July.

The other instance of group immunity was that of Barren Island, which lies in Jamaica Bay between Rockaway Point and the Flatlands, the city dumping ground. About 800 people live there who rarely visit the main land. Although all the refuse, rags and dead animals are sent there from the city, no case of poliomyelitis occurred.

In regard to the insect question, it may be said briefly, that as yet there is no well-established experimental evidence to show that insects play a regular part in the dissemination of the disease. The same negative result is true of investigations directed to demonstrate an association between human poliomyelitis and pet animals, rodents, and barn yard fowl. As a rule, localities which have been visited one year by an epidemic of poliomyelitis have fewer or no cases the next year. This fact is well shown in the studies of Kling and Wernstedt, which indicate that the converse of the proposition may be true. For it appears that places which are in the neighborhood of an epidemic area and escape infection very often are severely attacked the following year (Fig. 7).

A still unexplained phenomenon is the reappearance of the disease after several years in a place which had once been infected but which had been free during the interval. Such reappearances have usually been ascribed to the fresh importation of virus from an outside source. The recently published experiments of Flexner and Amoss,[35] however, showing the viability of virus preserved in glycerine for 4 to 6 years suggest another

possibility. If the virus is able to persist under adverse conditions for so long a period it may be that such reappearances as

FIG. 7.

those just referred to may depend on the reawakening of the original virus quite as well as upon a fresh importation.

The reports of the New York City and State Department of Health indicate very definitely that neither milk nor water supply was found to be associated with outbreaks of poliomyelitis in any locality. No evidence was to be had, moreover, that foodstuffs were responsible for the spread of the disease.

CHAPTER IV

EXPERIMENTAL POLIOMYELITIS

With the establishment of an almost constantly successful method of producing poliomyelitis in monkeys came the possibility of studying the nature of the virus, its mode of entrance into and exit from the body, its distribution in the various tissues of the body and its immunizing powers. A great number and variety of experiments have been made during the past few years but space does not permit a discussion of them all. The more important observations, however, and especially those which bear directly upon the interpretation of the human disease will be mentioned.

In the first place it was found that if a small quantity 1 c.c. to 3 c.c. of a 5 per cent. emulsion of the spinal cord of a child dead from poliomyelitis was injected into the brain of a monkey, the animal developed 7 to 10 days later signs of irritability and excitement followed by paralysis and death. It was then found that if such a cord emulsion were passed through the pores of a Berkefeldt filter that the clear filtrate possessed the power of setting up the disease as did the original emulsion, but with less regularity. When once the disease became established in the monkey it was a simple matter to transmit it through an indefinite succession of monkeys by means of intracerebral injections of the spinal cord emulsion from each last dead animal. Having obtained thus a virus capable of causing the disease regularly, it was possible to study its characteristics. The result of these investigations showed that the virus was capable of withstanding freezing for months, but, when dried within the substance of the spinal cord, it survived only for several weeks. It was destroyed or lost virulence rapidly if dried in an aqueous solution free from protein. To heat the virus is not at all resistant, being destroyed by 50°C. in a few minutes. "Hence," Flexner states, "it would

appear that while the infectious agent can survive in external nature, yet it is incapable of multiplying there, and needs to be protected by such substances as organic secretions, etc., that would prevent rapid and complete drying."

A rather unusual resistance is displayed by the virus to carbolic acid, which it withstands in solution of 0.5 per cent. strength. It is readily killed, however, by mercury bichloride.

There are various methods of inoculation which are successful in monkeys, but they are not all attended with the same regularity of success. The virus may be introduced subcutaneously, intraperitoneally, into the sheath of one of the large nerve trunks, or directly into the substance of the brain. The last method is more regularly successful than any of the others, especially with strains of virus which are fresh from a human case and have not yet become adapted by passage through monkeys. When the virus has become adapted to the monkey it is much easier to produce the disease with it. Indeed it is even possible by simply painting the nasal mucosa with a highly adapted virus to produce experimental poliomyelitis.

This experiment naturally lent strong support to the hypothesis formulated by Flexner and his co-workers that the main route of entry for the virus to the central nervous system was through the nasal mucosa and thence by way of the sheaths of the olfactory nerve filaments through the cribriform plate. Once arrived in the subarachnoid space the virus was disseminated rapidly by way of the cerebrospinal fluid. With the fluid it followed the invaginations of the arachnoid along the perivascular spaces of the anterior spinal vessels into the interior of the cord. This path of the virus can be followed by the advancing columns of cells which are thrown out in reaction all along the course of the vessels to their terminations about the anterior horn cells.

Further experiments determined the fact that the virus was present in the nasal mucosa and secretions of a monkey which had been given the disease by the intracerebral route. In other words, the nasal mucosa serve not only as a portal of entry but also as an exit for the virus.

By the same method of Berkefeldt filtration and intracerebral

injection of the filtrate of suspected material such as nasal and buccal secretions, and intestinal content, it was possible to demonstrate the presence of the virus in the latter situation.

Distribution in the Tissues.—Since the virus could not be detected by optical methods, inoculation experiments offered the only means of demonstrating its presence in any suspected material or tissue; but it has been possible in this way to determine in what tissue of the body, other than the central nervous system, the virus may exist. It was shown by Flexner and his co-workers to be present in a mesenteric lymph node and in the tonsils and pharyngeal mucosa; but it has never been detected in the spinal fluid or blood of human cases of the disease. This negative finding cannot be wholly explained now. It may depend upon the fact that no instance of the human disease has been studied sufficiently early in its course, or be due to the dilution of the virus in the fluid, besides which, it must be recalled that being taken directly from human beings the virus possesses low infective power for monkeys. The experiments of Clark, Frazier and Amoss show that after intravenous inoculation in monkeys, the virus of poliomyelitis disappears from the blood within 72 hours; and other observations have shown that it is only after enormous intravenous doses of the virus that the monkey develops the disease. Smaller doses intravenously fail to produce any disturbance.

In this connection, must be mentioned a series of experiments by Flexner and Amoss[36] upon the distribution of the virus in the body. These observers found that if a monkey be injected intravenously with 50 c.c. of an active virus no symptoms developed. If injected with 250 to 500 c.c. of the virus by a similar route the animal succumbed to the disease. By sacrificing animals so injected at various periods following inoculation they found that the virus was withdrawn from the blood, first, by spleen and bone marrow, next, by the posterior spinal ganglia, which are extradural and have a blood supply quite separate from that of the intradural portions of the central nervous system, and, finally, by the central nerve tissue itself. It was noted, however, that before the virus reached

the spinal cord the choroid plexus showed signs of injury. Experiments were then carried out which showed that, if a monkey were given an intraspinal injection of normal horse serum thereby setting up a sterile inflammatory reaction in the cerebrospinal space, subsequent intravenous inoculation with 50 c.c. or less of virus sufficed to produce the disease. If, however, immune monkey serum was injected intraspinally after the intravenous inoculation paralysis was prevented.

The foregoing experiments have recently been confirmed and their significance amplified by the experiments of Flexner and Amoss[37] upon the relation of meninges and choroid plexus to poliomyelitic infection.

From these latter observations has come an appreciation of the extreme delicacy of the mechanism for protection which these structures possess. For example, it was shown, as before, that an irritative meningitis set up by the intraspinal injection of horse or homologous monkey serum promoted infection by the intravenous route. Then followed experiments showing that when far less irritative fluids were injected intraspinally the meningochoroid defense was abolished. Thus, for example, injections of such physiologically accurate fluids as Ringer's or Lock's solution served to reduce the choroid defense so that infection followed intravenous inoculation of 50 c.c. of the virus. Indeed removal of spinal fluid and injection of the same fluid from another monkey sufficed in some instances to break down the defensive mechanism.

Nor was this promotion of infection through meningochoroidal injury limited to the results of intravenous inoculation. For it was found that infected intranasal cotton plugs, which failed to produce infection after two-hour contact in unprepared animals, did cause the disease if the animal had previously been given an intraspinal injection of horse serum.

Thus, by disturbing the delicately balanced protective mechanism of the meningochoroid apparatus infection of the cerebrospinal tract is promoted whether the virus enter by the intranasal or intravenous route.

In this connection must also be mentioned the fact demonstrated by Flexner and Amoss[37] that not only does

meningeal irritation promote the passage of blood borne virus into the cerebrospinal spaces, but also the passage of neutralizing substances or antibodies which are circulating in the blood.

This last point is of especial significance in connection with the problem of the serum therapy of the disease. For, if intraspinal injection of serum renders the passage of blood borne antibodies to the spinal fluid easy, then intravenous and subcutaneous injections of immune serum for therapeutic purposes as well as intraspinal injection are strongly indicated. As will be seen in the chapter on Treatment, this principle has been made use of by Amoss and Chesney in treating a series of human cases.

It is further significant that if the meningeal irritation be slight, caused perhaps by a nearly non-irritant fluid such as Locke's solution or spinal fluid, one intraspinal dose of immune serum serves to protect a monkey inoculated with the virus intravenously. On the other hand, several doses are needed when the meningeal damage is more severe. There seems to be therefore some quantitative relationship between the severity of meningo-choroidal injury and the amount of immune serum necessary to prevent paralysis.

This observation may be significant in view of the growing clinical experience that very mild cases, with only a small cell increase (below 100) in the spinal fluid, often escape paralysis when untreated.

The conclusions from these experiments are that the virus cannot pass from the blood to the cerebrospinal fluid and nervous tissues until there has been injury to the choroid plexus and meningeal blood vessels and lymphatics; and that the virus, which is in transit in the spinal fluid from the blood to the central nervous organs, can be neutralized by an immune serum which reached the subarachnoid space either directly or indirectly by subcutaneous or intravenous injection with subsequent passage through the choroid damaged by intraspinal injection. Finally, it has been shown that monkeys can be infected by intraspinous injections of properly virulent virus. Virus introduced thus into the cerebrospinal space diffuses with the fluid

along the membranes; in part it becomes fixed to the central nervous tissue and in part passes out with the spinal fluid into the blood by the regular channels. In the blood it is presumably lost. Virus which is injected into the spinal canal cannot be found in the spinal fluid later than 48 hours afterward. This helps explain the fact that the virus has not yet been demonstrated in the spinal fluid of monkeys or humans at the time of appearance of paralysis.

Immunity.—It is a well established fact both clinically in human beings and experimentally in monkeys that with perhaps an occasional exception one attack of poliomyelitis confers complete immunity; but efforts to develop an active immunity in monkeys without producing the disease have been attended with only partial success. For attempts to immunize by repeated injections of small or attenuated doses have occasionally resulted in the production of the disease, but it has been possible in some instances to develop an immunity by this method. Passive immunization has never been accomplished. The protection afforded by an attack of poliomyelitis in man was confirmed also for the experimental disease by Flexner and Lewis;[39] following which Römer and Joseph,[43] Landsteiner and Levaditi,[44] Flexner and Lewis,[45] Anderson and Frost,[49] demonstrated in the blood of recovered persons and monkeys substances capable of neutralizing the virus of poliomyelitis. These observations were followed by the therapeutic experiments of Flexner and Lewis[45], in which it was shown that the intraspinal injection of immune (convalescent) serum of monkeys and human beings protected monkeys from the otherwise fatal effects of an intravenous inoculation of the virus. It was upon this work that Netter[41] in 1912 based his report on the therapeutic employment of immune serum gathered from recovered cases. It is true that the blood serum of some persons who have not been paralyzed nor indeed even ever suspected that they have been victims of the malady may show neutralizing powers. But Netter has demonstrated that the serum of known non-paralyzed (so-called abortive) cases contains the neutralizing bodies. It is possible that these two last-mentioned facts may lend support

to the opinion expressed by some that many people may have poliomyelitis and never know it.

The Organism.—In 1914 Flexner and Noguchi succeeded in isolating an organism from the central nervous tissue of cases of poliomyelitis. Further study indicated that the organism was probably constantly present in the central nervous organs of fatal cases. Furthermore, artifically grown cultures of the globoid bodies, as they were called, in the ninth generation were capable of setting up the disease in monkeys.

Morphologically the organism appears as a very small globoid body measuring 0.015 to 0.03 of a micron in diameter. It occurs usually in pairs, small groups or short chains. The extremely small size of the microbe places it almost at the limits of visibility even with the strongest powers of the microscope. It stains best by Giemsa stain, and by Gram. It can be readily seen in the dark field microscope.

Culturally, it differs from the larger forms of known disease producing bacteria. Strictly anaerobic conditions are essential for its growth as well as certain special nutritive media. Human ascitic fluid in deep tubes with a bit of sterile kidney or brain tissue in the bottom forms the best medium. The whole is overlaid with paraffin oil. Growth is slow under the most favorable conditions.

Injection of culture of the globoid bodies into monkeys is capable of setting up poliomyelitis, typical both in symptoms and pathology. The globoid bodies, furthermore, may be detected by microscopic examination directly in the nerve tissue of human beings and monkeys dead of the disease. So far the organism may be said in general to have fulfilled Koch's law of causation.

CHAPTER V

PATHOLOGY

It is a striking fact that just as the attention of the medical profession was directed to the clinical picture of the disease of poliomyelitis by the chronic deformities of children, so our present knowledge of the extensive pathological changes began with the studies by Charcot and others upon the atrophic anterior horns of the gray matter. Our knowledge of the pathological and clinical features of the disease has developed rapidly and more or less equally in the past 10 years, with the result that in both fields have appeared indications that the lesions of acute poliomyelitis are not limited to the central nervous sytem. While several observers, Rissler, Harbitz and Scheel, Wickman, and Strauss, recognized the presence of changes outside the nervous system, they have not laid particular stress upon the systemic lesions. The visceral tissue changes, however, are sufficiently definite to form properly a part of the pathology of the disease.

In the experimental disease in monkeys the pathological changes are very uniform and characteristic. The several lesions may be considered as they affect first the meninges, second the spinal cord, third the medulla and pons, fourth the cerebrum, and fifth the ganglia.

The meninges of the cord and medulla show, as a rule, mononuclear cellular infiltration most pronounced adjacent to, or surrounding, the blood vessels which enter the fissures of the cord and are present in the floor of the fourth ventricle. The general infiltration of the pia-arachnoid is interstitial and as a rule, not heavy, while the invasion about the vessels within the perivascular lymphatics is usually heavy, and sometimes nodular. The spinal cord presents lesions most pronounced in the anterior gray matter, less marked in the posterior gray matter, and least present in the white matter. They are peri-

vascular, interstitial, and parenchymatous. The vascular lesions, which are often pronounced, extend inward from the meninges (Figs. 8 and 9); the interstitial ones are associated with the presence of mononuclear, to a less extent of polynuclear cells, of red corpuscles, and commonly of serum. Actual necrosis of the ground substance arises, but is uncommon on a large scale. The anterior gray matter is rarely wholly destroyed at certain levels. The interstitial lesions can, in some instances, be traced outward, directly from affected vessels. The lesions of the parenchyma consist of degeneration and necrosis of ganglion cells, occurring chiefly but not exclusively in the anterior gray matter. The necrotic cells are commonly in-

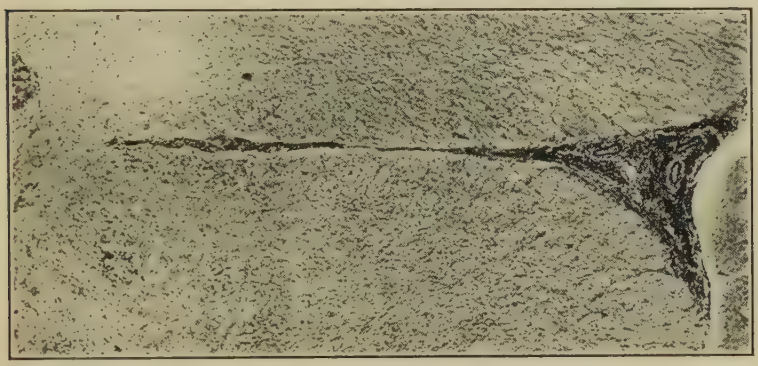

FIG. 8.—(Reproduced from the Monograph.)

vaded by phagocytes, the so-called neurophages. It is not usual for definite relation to be obvious between the altered blood vessels and the affected interstitial substance or parenchyma. The lesions of the medulla resemble those of the spinal cord, except as they are modified by differences in anatomical structure. The vessels most infiltrated are those present immediately beneath the fourth ventricle; the deeper lying vessels tend to be less affected, and the very small branches throughout the part are involved inconstantly. The focal interstitial lesions tend to be smaller than those of the cord. No definite relation can, as a rule, be made out between the vascular and interstitial changes. Because of the smaller size and less uniform distribution of nerve cells, the parenchymatous

lesions are less conspicuous; they are, however, essentially identical with those of the cord. Lesions similar to those in the medulla occur in the pons and crura cerebri, but less frequently. The cerebrum is affected far less constantly than other parts of the nervous system. When present, the lesions are perivascular and focal interstitial. The cerebral meninges, as a rule, escape affection. The choroid plexus of the lateral

FIG. 9.—(Reproduced from the Monograph.)

and fourth ventricles has not been studied in all instances. When the virus has been introduced experimentally into the brain, cerebrospinal fluid, or nerves, the rule appears to be that the plexus escaped. However, exceptions to this rule occur, in which case lesions similar to those described below as occurring after intravenous injection of the virus may arise. The intervertebral ganglia are invariably affected. The lesions are of two main kinds, interstitial and parenchymatous, and are

always focal. The cellular invasion proceeds from two sources; the pial investment and the blood vessels. In the former, direct extension may take place from the spinal meninges, or extension may occur by way of the connective tissue

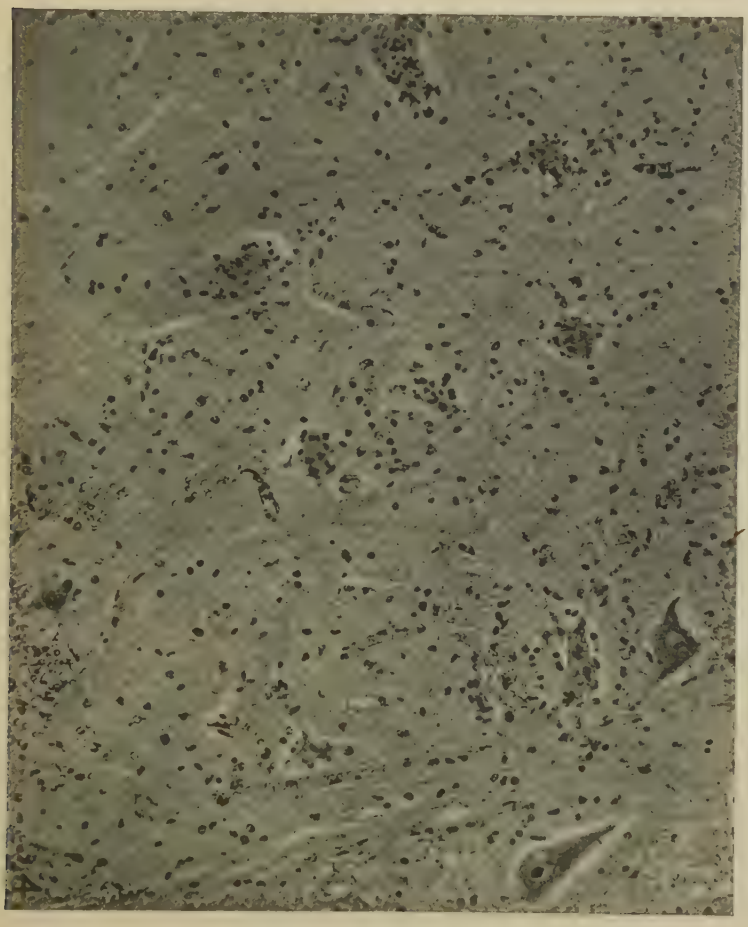

FIG. 10.—(Reproduced from *Journ. Exp. Med.*)

of nerve roots. In the latter, extension seems to proceed from the blood vessels. It remains, however, to state that the involvement of the blood vessels may not arise through the general blood, but through inclusion of the vessels in the infiltrative process within the septa of the nerve roots. In

rare instances the blood vessels present, as compared with other parts of the ganglia, an unusual degree of surrounding infiltration. The ganglionic nerve cells are destroyed in two ways: first, they are obliterated by focal accretions of mono-

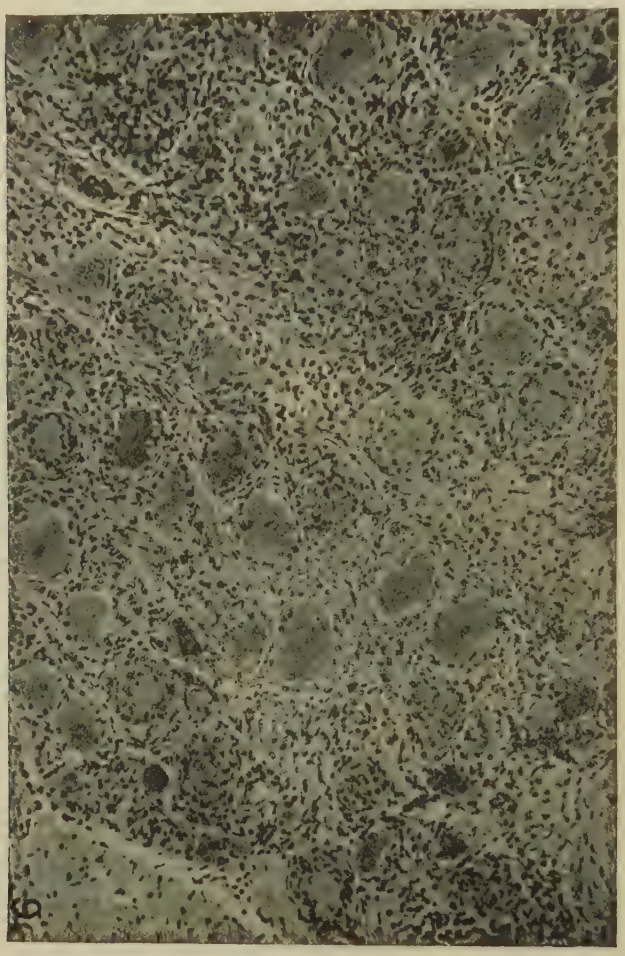

FIG. 11.—(Reproduced from *Journ. Exp. Med.*)

nuclear cells, and second, by necrosis and neurophagocytosis, in the same manner as in the corresponding condition in the spinal cord.

In addition to these facts Flexner and Amoss showed that

the character of the central nervous system lesions varied somewhat depending upon the method of inoculation. All the animals, whether injected intracerebrally or intravenously, showed the usual perivascular infiltration. But it appeared in several instances where large intravenous doses caused the disease that the blood vessels participated much more extensively in the lesion than when the inoculation had been by a neural route. Indeed the smaller vessels and capillaries were seriously damaged indicating the possibility for direct escape of virus from the blood into the nerve tissue. Besides these vascular lesions in the nervous tissue itself there were noted definite changes in the minute blood vessels of the choroid plexus. Damage to the ependymal cells was seen, with marked disturbances of the underlying vessels. So far as has been observed the type of lesions seen in sections of human cords from cases of poliomyelitis resembles more closely that seen in monkeys after the intracerebral mode of inoculation.

On opening the skull of a human case of acute poliomyelitis the dura appears congested. The pia arachnoid is also markedly injected and often œdematous. The surface of the brain looks wet and soft, and of a dark grayish-pink color. The same congestion and moist condition of dura and pia arachnoid is seen over the cord, and on cross section the gray matter usually bulges slightly and is dark pinkish gray in color. Frequently tiny hæmorrhagic points can be seen. Microscopically the earliest change which can be seen is a perivascular infiltration of small round cells along the blood vessels of the leptomeninges. These perivascular lymph spaces, being prolongations of the arachnoid spaces are free to the access of cerebrospinal fluid. If our conceptions of the pathogenesis of the disease is correct, it is obvious that the virus, having penetrated the injured choroid plexus, is suspended in the spinal fluid and is conveyed thus along these perivascular lymph spaces. As it travels it calls forth the characteristic tissue reaction, a pouring out of small round cells, chiefly of mononuclear type. Recently Blanton[46] has shown, by means of the oxydase reaction, that among the mononuclear cells of the exudate may be many granulocytes. The whole cellular outpouring is so great as to

choke the spaces and bring pressure to bear upon the surrounded blood vessel. The process then advances from the parietal meninges and enters the interior of the cord by the anterior fissure along the branches of the anterior spinal artery. In addition to the cellular exudate the pial vessels themselves are extremely engorged and frequently the damage to the smaller and more delicate arteriole walls is so great that localized hæmorrhage occurs. That the lesions are not confined to the anterior grey matter of the spinal cord, but affect also the posterior, and even the white matter, has been often observed. As now viewed pathologically, the older name for the disease, "anterior poliomyelitis," is hopelessly mistaken. Besides this interstitial reaction with its cellular infiltration, hæmorrhage and œdema, which exert pressure upon the cells of the anterior horn there appear definite changes in the ganglion cells themselves.

These cells show all stages of degenerative change from the slightest swelling and loss of Nissl's bodies to complete destruction. Particularly interesting are the observations that uninjured ganglion cells may be found side by side with other ganglion cells exhibiting extreme injury and lying in a region of advanced cellular infiltration. On the other hand, disintegrating cells can be seen in sections which are strikingly free from infiltration. When the degenerative process in the cell is well under way polynuclear cells wander in and occupy the degenerated cell—often several in a cell, and form the so-called neurophages.

Cord lesions, however, are not limited to the vessels and the ganglion cells. There is besides a diffuse cellular infiltration throughout the gray and white matter. These interstitial changes may reach extreme grades. So that, in addition to the lumen narrowing collars of cells which surround the blood vessels, œdema, hæmorrhage, and cellular infiltration increase the burden under which the anterior horn cells have to labor.

Obviously, then, the injury to the central nervous tissues is a severe and diversified one. There is still some question whether or not the degeneration of the anterior horn cell depends solely upon the effect of pressure from hæmorrhage

and œdema and the choking off of blood supply, or whether there may also be from the virus a direct toxic effect upon the cell; but the weight of opinion is in favor of a combined direct toxic action. The probability is that all the forces are operative and that the anterior horn cells are both poisoned and strangled to death.

Attention has been drawn to the general nature of the infectious poliomyelitis process, and in conformity with this fact, Flexner, Peabody and Draper described wide-spread visceral lesions, in the lymphatic organs especially. They consist of hyperplasia of lymphatic glands, of spleen, intestinal lymphatic nodes and interstitial small cell infiltration in the portal spaces of the liver, and general cloudy swelling of the organs. The focal hepatic neuroses described by them have not been confirmed by other observers, and may have been accidental in these cases. The tonsils and pharyngeal lymphatic structures likewise share in the hyperplasia.

CHAPTER VI

CLASSIFICATION OF TYPES OF POLIOMYELITIS

Almost all existing classifications of the disease are based upon the situation of the lesions in the central nervous system. The absence of muscle weakness was the criterion for giving a case the misleading name "abortive." As our knowledge of the disease has increased we have come to realize more and more that the three important terms used in connection with the malady are bad misnomers. Poliomyelitis, infantile paralysis, and abortive are not only incorrect terms as regards fact, but they have produced a habit of thought about the disease which has done much to retard the growth of a clear understanding of the pathological and clinical mechanism of the infection. Ever since Wickman pointed out the clinical fact that there were cases of poliomyelitis which never developed paralysis it has become increasingly evident that the extent of this group is much larger than was at first supposed. The exact number of these non-paralyzed cases doubtless varies in different epidemics and may perhaps depend upon the relationship of variations in virulence of the infectious agent and differences in individual susceptibility. But all observers agree that they represent at least 50 per cent. of the total incidence of the disease, and some place the figure as high as 70 to 80 per cent. Even if the lower valuation be accepted as correct, any system of classification based upon paralysis fails to cover, save by sweeping exclusion, a full half of the recognized cases. The question then arises whether or not there are other features of the disease which appear with sufficient frequency and constancy to form criteria for classification. One of the phenomena which led Wickman to suspect the presence of non-paralyzed cases was the appearance, in the family of a paralyzed child, of other children presenting acute febrile or gastro-intestinal disturbances similar to those seen in the paralyzed case. In other

words, the non-paralyzed and paralyzed cases presented a similar set of general symptoms. Müller carried this observation a step further when he pointed out that epidemic centers in different sections of the country supplied examples of somewhat different types of the acute systemic stage of the disease. Thus, in one area gastro-intestinal disturbances predominated while in another there were chiefly found cases with inflammation of pharynx and tonsils. He further notes that the non-paralyzed cases in a given locality presented the same particular set of general symptoms, which had preceded the advent of muscle weakness in the paralyzed cases of that locality.

Obviously then we are dealing with a disease which has two distinct phases, one of general systemic nature and another of specialized expression in the form of central nervous system disorder. Furthermore, there may be a variety of symptom complexes representing the systemic phase.

With these facts in mind it is apparent that a classification of the disease in terms of the paralyses is quite inadequate and obsolete and that some new arrangement must be made.

Perhaps the most suggestive phenomenon of the whole disease is the similarity between the acute systemic phase of the paralyzed cases and the whole course of the non-paralyzed ones. Consequently, the question arises as to what the relationship is between the general systemic phase and the secondary localized central nervous system phase of the malady.

In the Monograph there appears a discussion of the prodromata of the disease. Here are considered the various symptoms and their arrangement, which precede the advent of paralysis. Several different forms of prodromal expression are mentioned, notably a series of digestive tract upsets and fever which become increasingly severe until paralysis appears. Attention, however, is also drawn to the occurrence of prodromal phenomena which clear up entirely or almost entirely, so that for a day or so the child appears to have recovered. "Nevertheless" runs the text at this point, "one or two days later, and perhaps without warning, the child becomes paralyzed."

It is this curious manifestation of two distinct phases or

periods in the course of the disease which this study attempts to analyze and explain. Though previously recognized by us, the full significance of the phenomenon was but vaguely appreciated. No attempt was made to correlate the events which, though apparently separate, both in regard to time and character, in reality formed the complete expression of the disease.

Because of the opportunity to observe large numbers of cases almost from the first moment of illness during the epidemic on Long Island, it was possible to classify the cases by their clinical symptoms in the acute or febrile stage of the disease.

Three distinct groups have been separated. In the first two groups there develops a picture of general systemic infection from which the child appears to recover completely or in part, then to receive a second blow directly upon the cerebrospinal tract.

Because of the two definite masses or humps of symptoms, the analogy to the arrangement of the dromedary's back was taken to express the type figuratively. The temperature curve may show one or two elevations but the figure refers to all the signs and symptoms of each group or hump whether there is an associated rise of temperature or not. The total duration of the combined phases may vary from a few hours to many days, while the intensity of either phase, the systemic or the meningeal, may touch the extreme of violence or such mildness as to escape detection.

The first series called the "dromedary" group, shows clearly two distinct periods of illness with an interval of well being (see Cases 1–15). In the second series, called the "straggling" group, this period of comparative well being is not present, but there is a sustained course of indisposition of varying intensity (Cases 16–24). In the third, or sudden onset group, all the signs point from the start to meningeal and nervous tissue involvement (Cases 25–31). A striking feature of the whole series is that the second portion of the first two groups is very similar to the whole course of the sudden onset group.

The first hump of the dromedary type and the continued course of the straggling group is composed of a febrile movement with symptoms falling into three main categories—gastro-

intestinal, tonsillar and upper respiratory passage inflammation and general malaise without localization of symptoms. Pursuant then to a remission of all symptoms in the dromedary group, or a varying duration of symptoms in the straggling group, one of two things occurs—the patient promptly gets well or sudden evidence of meningeal involvement appears from which may follow recovery or paralysis.

Experiment has shown that the virus gains entrance with difficulty to the central nervous system tissues of monkeys subjected to intravenous inoculation. In human subjects the number of cases recognized as never giving the slightest indication of central nervous system invasion is steadily growing with our experience. There are so frequently found in families where a frank paralytic case occurs, other children who present persistently the same symptoms which the paralyzed child has shown in the preliminary hump, that one is led to suppose that these may be examples of infection in which no penetration of the meninges occurred.

In the straggling group the same interpretation applies, the only difference being that these individuals present a continuous course with a fusion of the symptoms of the two stages. Sudden onset cases may be looked upon as examples of the malady in which the systemic stage has been overlooked because of its triviality. In this group the spectacular and violent picture of meningeal disease dominates and drives the memory of the slight preceding indisposition from the mother's mind. It is very difficult under these circumstances, to get from the family any history of the child being unwell during the preceding days.

We have included in this group of sudden onset, Case 41 (treatment series), where the child was punctured at 1 A.M. having gone to bed well. This case might have been reported as one where the child awoke with a stiff neck and high fever. Yet the parents of this child remembered that for two days previously there had been a slight and unimportant disturbance of the bowels. In other words, this case with sudden meningeal onset was an instance of typical dromedary course in which there was a preliminary hump so mild as almost to escape appreciation.

The Case 25 (Diagnostic series), is another instance in which no history of early indisposition was obtained at the time of the acute onset. But later on, after the excitement of the

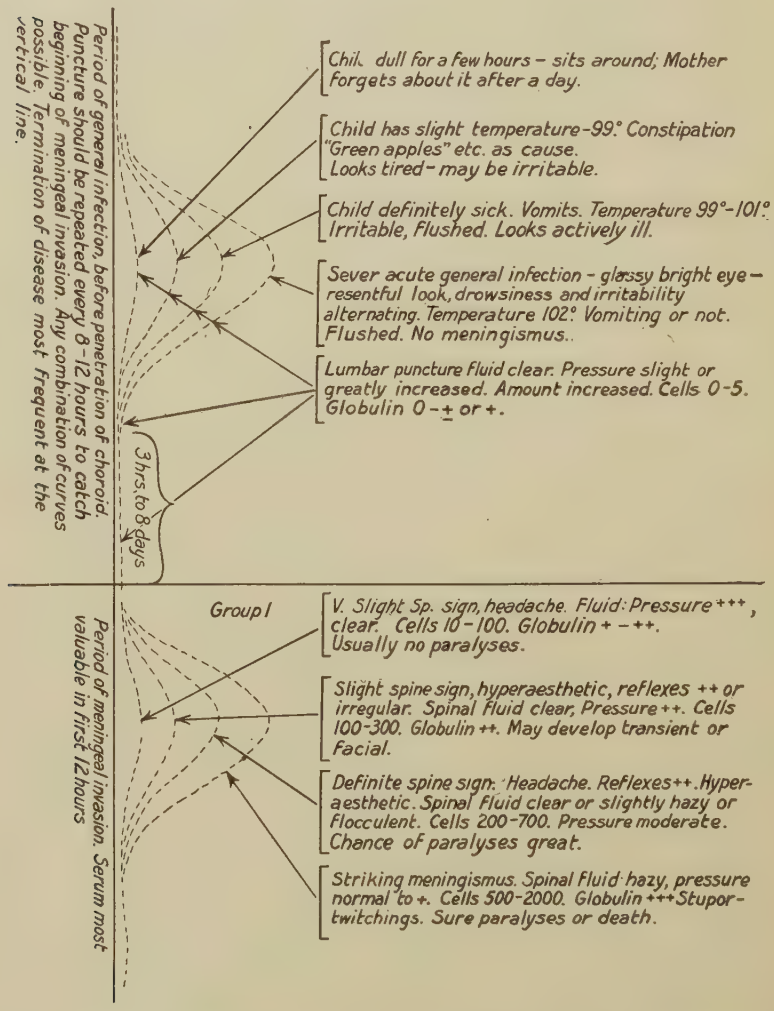
Period of general infection, before penetration of choroid. Puncture should be repeated every 8-12 hours to catch beginning of meningeal invasion. Any combination of curves possible. Termination of disease most frequent at the vertical line.
Chil. dull for a few hours – sits around; Mother forgets about it after a day.
Child has slight temperature-99.° Constipation "Green apples" etc. as cause. Looks tired – may be irritable.
Child definitely sick. Vomits. Temperature 99°-101.° Irritable, Flushed. Looks actively ill.
Sever acute general infection – glassy bright eye – resentful look, drowsiness and irritability alternating. Temperature 102° Vomiting or not. Flushed. No meningismus.
Lumbar puncture fluid clear. Pressure slight or greatly increased. Amount increased. Cells 0-5. Globulin 0-± or +.
3 hrs. to 8 days
Group I
V. Slight Sp. sign, headache. Fluid: Pressure +++, clear. Cells 10-100. Globulin + -++. Usually no paralyses.
Slight spine sign, hyperaesthetic, reflexes ++ or irregular. Spinal fluid clear, Pressure ++. Cells 100-300. Globulin ++. May develop transient or facial.
Definite spine sign. Headache. Reflexes++. Hyperaesthetic. Spinal fluid clear or slightly hazy or Flocculent. Cells 200-700. Pressure moderate. Chance of paralyses great.
Striking meningismus. Spinal fluid hazy, pressure normal to +. Cells 500-2000. Globulin +++ Stupor-twitchings. Sure paralyses or death.
Period of meningeal invasion. Serum most valuable in first 12 hours

FIG. 12.

affair was over, the mother recalled that the child complained of headache and malaise a day or two before.

In a few instances lumbar puncture has been made during what apparently was the first hump and the fluid at this stage

has been practically negative. There may be a very slight suggestion of globulin increase as appeared in two or three cases, but the pressure and volume of the fluid has in almost all instances, been increased. The second puncture in these cases, made after the signs of meningeal invasion have appeared, has shown fluids with cell counts all above normal.

If the observations of Flexner and Amoss upon the effects of intravenous inoculation of virus in monkeys now be recalled (see page 25), the clinical course of the disease as just discussed can possibly be subjected to a more logical interpreta-

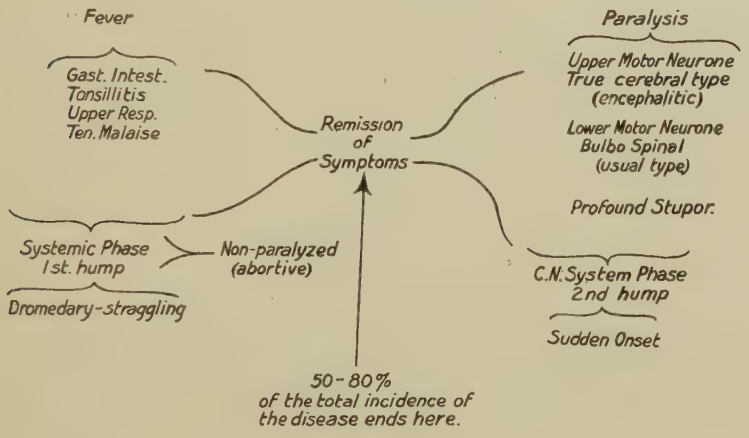

FIG. 13.

tion. A suggestive analogy becomes apparent between the first febrile period of the dromedary or straggling types and the phenomena of lodgment of the virus in the spleen and bone marrow of monkeys after intravenous inoculation. Likewise the second hump in the human case, with its central nervous system involvement, corresponds to the late disclosure of the virus in the central nervous tissue of the monkey.

The accompanying plan (Fig. 12) shows a schematic form of the foregoing interpretation of the disease.

A possible classification therefore of the disease as a whole on the basis first discussed is indicated in Fig. 13.

DIAGNOSTIC SERIES

DROMEDARY GROUP

Case 1.—S. L. Boy. Age 9 years. Northport, L. I.

September 8, 1916. Child complained of headache and fever. Lasted 24 hours. He was then all right until 2 days ago.

September 17, 1916. Headache and fever returned (8-day interval). Was constipated for following 2 days.

September 19, 1916. Vomited several times during the last 18 hours. His temperature was 100.4°. Muscle tenderness in the thighs and calves. Suggestion of left facial weakness. No spine sign.

Lumbar puncture at 48 hours. Fluid clear, pressure normal, cells 40. Globulin negative. No further paralysis developed.

Discussion.—This case illustrates the common phenomenon met in this disease of two distinct febrile periods with a free interval. Here the first period lasted 24 hours, the interval 8 days (rather longer than usual), and the second period 18 to 24 hours. In the last period the facial weakness developed.

This we have called the "dromedary" type of case because of the two "humps" in the temperature curve.

Case 2.—H. C. G. Boy. Age 5 years 6 months. Port Washington, L. I.

August 15, 1916. Vomiting several times and complaining of pains in stomach. Temperature at this time ranging around 101°. This continued for 24 hours when the temperature dropped, the patient ceased to vomit and felt as well as usual.

August 18, 1916. This morning, 8 hours ago, patient began to complain of pain in left leg. Father stated that during sleep boy had muscular twitching confined chiefly to the arms and legs. Attending physician states on seeing him this morning could not detect any definite paralysis, but thought the left leg was weak, as he was not able to contract the thigh as he should.

Physical examination showed the patient in a comatose state and when awakened or aroused the eyes are staring and glassy in appearance. No ocular weakness, no facial weakness, throat negative. Neck markedly rigid. Abdomen distended. Extremities, aside from slight movements in toes and external rotator of thigh, both legs paralyzed. Left completely. Paralysis of erector spinæ.

Reflexes.—Knee jerks absent on both sides. Puncture not done.

Discussion.—In this instance the first hump is definitely associated with gastrointestinal symptoms, and the second with central nervous system symptoms. The free interval is clean cut and of about 48 hours' duration.

Case 3.—M. L. Age 3 years. Patchogue, L. I.

August 23, 1916. Temperature 104°. Wanted to lie down.

August 24, 1916. Temperature 99.5°. No signs. Well until

August 28, 1916. "Feverish" last night. Examination was negative except for a slight left facial paralysis. No puncture was made.

August 31, 1916. Reported by Dr. Overton to have died from sudden respiratory failure yesterday A.M. after removal to the hospital.

Discussion.—This case is rather unusual in the development of respiratory failure 3 days after the establishment of a facial paralysis without other muscles involved. It is a well-marked dromedary type. No puncture was made.

Case 4.—M. T. Boy. Age 8 years. Oyster Bay, L. I.

August 13, 1916. Child began to complain. A little drowsy, slight headache. Was taken to the family physician who found the temperature 102°. Was given a cathartic and the condition apparently cleared up.

August 18, 1916. The child began to feel drowsy again and had no appetite, refused breakfast, and complained of slight headache. A doctor was called in who suspected the case to be one of poliomyelitis. Temperature registered 102°.

Physical examination showed the eyes "glassy." Mouth and nostrils negative. Very slight rigidity of the neck. Extremities show no paralysis or muscular weakness.

Reflexes.—Knee jerks inconstant, but when obtained are active. No Kernig.

Lumbar puncture at 12 hours. Fluid clear under moderate pressure, about 8 c.c. obtained. Cell count 40. Noguchi plus. Albumin plus.

August 21, 1916. In Locust Valley Hospital, doing well, no paralysis.

Case 5.—L. C. Girl. Age 3 years. Port Washington, L. I.

August 26, 1916. Child had a chill followed by fever. This occurred again 2 days later. The mother thought this might be malaria, and gave the child quinine. Appetite was poor for 3 days and the child was restless and irritable.

September 1, 1916. Mother noticed that the child was unable to walk. She crawled about on her knees. She had always been well until last winter when she had measles and pertussis.

September 2, 1916. *Physical examination* showed a robust, well-nourished child with large tightly fitting teeth. Legs were drawn up in flexed position and it is extremely difficult to straighten them out. They are quite tender. Kernig is very positive. Neck is stiff and child is tender along the spine. Child feels feverish and is hyperæsthetic.

Reflexes.—The knee jerks were not obtained.

Child has not vomited. Bowels are constipated.

Spinal puncture at 48 hours. Pressure was 16 mm., reduced to 6 after withdrawing about 15 c.c. of fluid. Cell count 40. Globulin ++.

September 3, 1916. Child much better to-day. Legs have straightened out. No temperature. No paralysis.

Discussion.—In this instance the remission of symptoms is not complete. The appetite was poor and the child irritable for a period of 3 days. The first hump is unusual in having an irregular or divided curve resembling malaria. The second hump is not strongly marked and the meningeal invasion appears to advance slowly during 2 days (September 1st and September 21st). The cell count is low. No paralysis developed but there was a slight weakness of the lower extremities for a time.

Case 6.—R. S. Girl. Age 12 years. Babylon, L. I.

August 14, 1916. Child taken sick with chill and fever. No diarrhœa.

August 15, 1916. Vomited after taking castor oil the night before.

August 16, 1916. Patient feels much better and does not seem to have any fever according to the mother.

August 17, 1916. Patient complained of pain in her eyes, head, back of neck when attempting to flex it. No cough, slight drowsiness. Temperature 103.2°.

August 18, 1916. Temperature 103.2°. *Physical examination* showed the eyes negative, neck extremely rigid, pain being caused on attempt to flex the neck or spine. Cervical and inguinal glands palpable. Throat very red with small white patch confined to the left tonsil. Lungs negative. Slight systolic murmur, heart loudest over the apex and transmitted to the axilla.

Reflexes.—All reflexes normal.

Slight ataxia. Abdomen negative.

Lumbar Puncture.—Fluid clear under slightly increased pressure. Cell count 690. Pandy, Noguchi and Ross Jones +.

September 22, 1916. Diagnosis. Acute anterior poliomyelitis.

September 23, 1916. Temperature normal. Patient has recovered with spastic action of both feet when walking.

Discussion.—The intermission in this case is of short duration. Note localization of symptoms in the head and neck with onset of second hump. Again the very high cell count presaged damage to the central nervous system tissue. In this instance, however, flaccid paralysis did not occur, but a marked spasticity persisted.

Case 7.—T. R. D. Boy. Age 3½ years. Babylon, L. I.

August 5, 1916. Bilious. Vomiting and headache, then well for 3 to 4 days.

August 11, 1916. Has had pain in the stomach for 2 days. Temperature normal. Child restless, irrational.

August 12, 1916. Temperature 100.5°. No paralysis.

Spinal puncture at 24 hours. Slight turbid, blood. No increased pressure. 980 lymphocytes. Red blood corpuscles present.

September 3, 1916. Complete recovery. No paralysis.

Discussion.—Again a marked free interval. Note especially the very high cell count, 980. Even though red blood cells appeared in the fluid there were not enough to explain the great number of lymphocytes. That this case should have recovered without paralysis is unusual in view of the high count at such an early hour.

Case 8.—V. C. Boy. Age 6 months. Hempstead, L. I.

August 15, 1916. Child began to be sick. Vomiting and diarrhœa followed eating ice cream. Temperature 100°. This dropped to normal and the child was better for an interval of about 36 hours. The temperature then rose.

August 18, 1916. Neck rigid and reflexes normal. Right arm shows loss of power, not complete.

Knee jerks. Right negative; left positive; also weakness of the right thigh. No Kernig. Anterior neck muscles weak.

Spinal fluid at 18 hours. Clear. Pressure ++. Cells 250.

Case 9.—D. S. Girl. Age 4½ years. Bayshore, L. I.

August 9, 1916. The child vomited and had a sore throat on this and the following day. She was then apparently well for 4 days.

August 15, 1916. Headache. Temperature 103+°. Stiff neck.

August 16, 1916. Temperature 101° (axilla). Lungs negative. Examination otherwise negative except for drowsiness.

Spinal puncture at 48 hours. No increased pressure, 188 cells, 50 per cent. mononuclears.

September 1, 1916. Child well. Never developed paralysis.

Discussion.—The differential count showing 50 per cent. mononuclears indicates that the meningeal process is no longer very early and agrees with the time of puncture as estimated from the symptoms.

Case 10.—H. P. Girl. Age 20 months. Oyster Bay, L. I.

July 15, 1916. Child began to be sick. Fever and vomiting lasting 1 day. The next day she appeared to be well. Temperature 98°.

July 17, 1916. Temperature 102°. Knee jerks absent. Walked normally. Badly constipated.

Spinal puncture at 24 hours. Fluid clear. Pressure +. Few flocculi. Cells 40.

Physical examination showed no spinal tenderness or rigidity.

Knee jerks were absent. Patient otherwise normal. No paralysis developed. The child made an early recovery.

Discussion.—Mild case. The first febrile period was about 24 hours long; free interval 36 hours and the final febrile period about the same length. Lumbar puncture performed 24 hours after the second hump showed 40 cells.

Case 11.—O. R. Girl. Age 7 years. Patchogue, L. I.

August 18, 1916. Temperature 101°. Feels poorly. Next day well again. Temperature normal for two days.

August 21, 1916. Rise of temperature to 101.5°. Twitching of the arms. Does not seem very ill.

Spinal puncture at 24 hours. Pressure +. Cell count 1180, 60 per cent. mononuclears.

August 23, 1916. Died of respiratory paralysis.

Discussion.—This is an example of the dromedary type of case with a 2-day interval. In the meningeal stage of the disease there is some discrepancy between the mild clinical picture which the child presented and the very high cell count.

Case 12.—H. P. Boy. Age 8 years. Garden City, L. I.

August 5, 1916. Sudden onset of illness. Fever rising to 102°. Slight sore throat.

Physical examination otherwise negative.

August 7, 1916. Temperature 100°. Examination at this time showed red throat; tender slightly enlarged upper left anterior cervical node. Otherwise negative. There was no change in the neck, spine, nerve reflexes or muscles. The diagnosis was *called negative.*

August 10, 1916. Temperature rose rapidly to 102°. Child was drowsy, vomiting twice; had headache and seemed prostrated. During the next 6 hours he became progressively worse, showing a temperature of 102°, flushed face, widely dilated pupils. Stiff, retracted hand and neck; stiff unbending spine. There was no paralysis or changes in the reflexes except the Kernig sign which was markedly positive. Typical projectile vomiting. Consciousness was clouded, with short periods of delirium.

Diagnosis.—Poliomyelitis and encephalitis. At request of family physician puncture was not made at this time. The following day at 48 hours spinal puncture showed a clear fluid under slight pressure, with a cell count of 260. The clinical course was rapidly and progressively worse, with accentuations of all the findings, and finally death. No muscular paralysis could be made out.

Discussion.—This is a case of overwhelming severity. The free interval is well marked. The diagnosis at the time of the first hump was negative owing to the entire absence of signs pointing to the central nervous system involvement. The delay in puncturing was unfortunate.

Case 13.—F. M. Age 18 months. Glen Cove, L. I.

August 10, 1916. Child ill with fever and slight diarrhœa consisting of several watery movements a day. This lasted 2 days when the child began to be petulant and peevish. The fever after the first 2 days of illness remained normal.

August 16, 1916. For the past 24 hours the child has cried when

touched. The neck has been stiff and retracted and the back stiff and tender. The temperature is 98.4°. The temperature has been repeated and is correct. The neck is tender and retracted. Spine is arched and tender. The knee jerks are normal. There are no paralyses. Physical examination is otherwise negative.

Spinal fluid at 24 hours. Clear under pressure. 200 cells. No paralysis developed.

Discussion.—This case presents a free interval of 4 days. The most unusual point about the second hump is the absence of elevated temperature. Signs of meningeal irritation are present, however, both by physical sign and laboratory evidence.

Case 14.—V. L. Girl. Age 3½ years. Lynbrook, L. I.

July 3, 1916. Patient returned from a motor trip feeling cold and chilly. That evening had slight fever and felt indisposed. The fever continued for three days when a physician was called.

July 6, 1916. Temperature 100°. No pain. No stiffness. Bowels regular. Cathartic was given on the night when the fever first appeared. For four days following this the child felt well and played out of doors in the yard.

July 11, 1916. The child vomited during the night and had fever.

July 12, 1916. Child slightly listless and more than uncommonly quiet. Temperature 100.16+°.

July 15, 1916. Temperature 101.11+°. The child has remained up and about the house. Appetite is indifferent. The child asks for sweets and cake. Physical examination at this time shows a very well-nourished child, quiet but not appearing sick. Eyes normal. Throat normal. Knee jerks are present; other reflexes are normal. No motor disturbances.

Lumbar puncture at 72 to 96 hours. Fluid came in drops with possibly increased pressure. Clear. Cell count 140. Mononuclear cells predominating. Globulin +.

Discussion.—A mild case showing well-marked dromedary form. The free interval is about 4 days.

Puncture performed on the fourth day following the second hump. There were still 140 cells per c.c. The puncture was made late in the second hump, after the child had begun to be better again.

STRAGGLING GROUP

Case 15.—D. M. Girl. Age 4 months. Hicksville, L. I.

August 24, 1916. Child was noticed to be feverish.

August 25, 1916. Physician was called and found a temperature of 103°. Patient seemed sick but without any apparent reason.

August 26, 1916. Seen again, temperature 102°, still constipated but no other signs of illness.

August 29, 1916. At noon temperature 101.8°, still constipated, much more drowsy and sick looking; shows no paralysis. Yesterday, though not seen by physician, mother noted that the head was held stiff and the baby cried whenever it was moved. To-day the patient appears sick, sweating and drowsy. Has a slight spine sign, no Kernig and no paralysis.

Lumbar puncture after 24 hours. Fluid under slightly increased pressure, clear, cell count 337. Knee jerks ++. Noguchi ++++.

Case 16.—L. W. Girl. Age 4½ years. Great Neck, L. I.

August 6, 1916. Child developed a temperature of 101.6°, pulse 100 to 110.

August 11, 1916. Since onset has been apathetic and at times very irritable. Bowels constipated. Complained of sharp shooting pains in the abdomen. No vomiting.

Physical examination shows marked hyperæsthesia, particularly along spine. Marked rigidity of the neck. Marked Kernig on both sides. Knee jerks, left not obtained, right very active. Abdomen negative.

Lumbar puncture at 24 hours. Fluid clear under moderate pressure. 370 cells. Noguchi +. Albumin +.

This case never developed paralysis.

Case 17.—M. A. Boy. Age 4½ years. Port Washington, L. I.

August 17, 1916. Child has been drowsy and very irritable for several days.

August 18, 1916. This morning had fever. Headache and pain in the back of the neck last night, about 12 hours ago. Was constipated for several days previous to this and was given numerous cathartics without success. Mother states that last night she gave the child castor oil but he vomited it. The family physician saw the child about an hour ago and found his temperature 103°.

Physical examination shows the boy lying in bed and apathetic. Eyes staring and glassy in appearance. Tonsils and pharynx considerably congested, but without exudate. Heart and lungs negative. Abdomen normal. Extremities: No paralysis or muscular weakness. Knee jerks markedly exaggerated, ++++. Most marked on the left side. Kernig marked on both sides, most on the left. Skin reflexes are active. Slight rigidity of the neck, hyperæsthesia.

Spinal puncture at 12 hours. Fluid clear under pressure. About 12 c.c. obtained. Cell count 250.

September 2, 1916. Patient seemed to be completely well 24 hours after puncture and has had no subsequent paralysis or complications.

Discussion.—This is an example of the unimportant impression that the early days and hours of the disease make upon the mother. Yet the suggestion is clearly of an indefinite period of "out of sorts" preceding the headache of August 18th.

Case 18.—D. S. Girl. Age 4 years. Hicksville, L. I.

August 13, 1916. Mother noticed that the child had a fever of 103°.

August 14, 1916. Child vomited.

August 15, 1916. Child was given calomel, had two movements and temperature 102°.

August 16, 1916. Temperature 101°.

August 17, 1916. Temperature normal. Yesterday morning she was given castoria, last night and this morning castor oil, but no result. She vomited again on this day. Very drowsy, somewhat irritable when disturbed, and has complained of headache.

Physical examination shows weakness in the back when sitting up. Some rigidity of neck. Arm and abdomen reflexes present. Station wide. Marked ataxia. Eyes and throat normal.

Lumbar puncture at 108 hours. 10 c.c. fluid, clear, under no increased pressure. Cell count 220. Noguchi +. Pandy +. Ross-Jones +. Knee jerks absent. Slight weakness of right quadriceps. Plantar reflexes present. Child was quarantined at home.

August 18, 1916. Died of respiratory paralysis at 5 P.M.

Case 19.—E. H. Girl. Age — —. Mineola, L. I.

August 19, 1916. Child began to complain of headache and feeling warm. Temperature 103°. No vomiting or diarrhea. Child drowsy, slept at short intervals throughout the day.

August 20, 1916. Child seen by Dr. Tibbets. Temperature 102°.

August 22, 1916. Pain in the back and back of neck, temperature 100.4°.

August 23, 1916. Not seen by physician.

August 14, 1916. *Physical examination* showed a well-developed child, up and around the house walking; eyes normal; throat slightly congested. Palpable cervical and inguinal glands; heart and lungs negative. Abdomen: Liver slightly enlarged one finger below the costal margin. Extremities: slight muscular weakness of the left leg. Child walked with limp, no pain. Knee jerks both present, less on the left side. Other reflexes normal. No Kernig.

Lumbar puncture at 48 hours. Fluid under tension, clear, about 6 c.c. obtained, cell count 50. Globulin + —.

Discussion.—Cases 15 to 19 illustrate a straggling course in which the invasion of the meninges is rather more sharply marked than in many.

In Case 15 the mother had noticed that the head was held stiff and that the child was hyperæsthetic. Cases 17 and 19 illustrate what an unimportant impression the first part of the disease makes on the family. These cases hold out more hope of early recognition at the onset of meningeal stage than on those which follow.

Case 20.—J. M. Boy. Age 3 years. Port Washington, L. I.

August 16, 1916. Illness began with a cough and fever during the night

which continued for 3 days. Vomited several times in the beginning and complained of pain in the stomach.

August 19, 1916. This morning on getting out of bed fell on the floor and after some difficulty succeeded in getting to his feet, but walked with difficulty, dragging his right leg. Physician was called in and temperature found to be 103°.

Physical examination showed eyes normal, mouth and teeth in good condition, tonsils and pharynx slightly congested. Lungs: marked bronchitis, many sonorous râles heard throughout the chest. Heart: no murmurs. Rate 100. Abdomen: normal. Extremities: marked weakness on rotating leg outward of right side and extension of thigh upon hip. No rigidity of neck. No Kernig. Reflexes: knee jerks, left leg is absent, right active and constant.

Lumbar puncture after 72 hours, fluid clear, under no tension, about 4 c.c. obtained. Cell count 240.

Note.—In this instance, one of the few seen in the Long Island epidemic, respiratory tract symptoms predominated.

Case 21.—M. E. A. Girl. Age 4 years. Wheatly Hills, Old Westbury, L. I.

August 8, 1916. Child began to be ill with slight headache and was very irritable, running a temperature of 101° and 102°. No gastric disturbances. Bowels constipated.

August 11, 1916. *Physical examination* showed the patient somewhat languid. Eyes are normal. Abdomen normal. Extremities: no muscular weakness or paralysis. Knee jerks are present and equal. No Kernig.

Lumbar puncture at 72 hours, fluid clear, under moderate tension, about 8 c.c. obtained. Cell count 200. There were no signs of central nervous system involvement.

Note.—Patient's brother James, aged 7, was sick from July 2d to 4th, vomiting and fever, which was thought to be a simple gastric enteritis and was treated for such.

August 12, 1916. Child removed to Roslyn Hospital.

August 19, 1916. Child has developed a distinct weakness of the left tibialis.

Discussion.—There is no clear indication in this case when the meningeal invasion began. The very mild character of the infection and especially the lack of symptoms of meningeal irritation are interesting in view of the rather high cell count. The delayed appearance of weakness is unusual.

Case 22.—R. B. Girl. Age 3 years. Sea Cliff, L. I.

August 5, 1916. Illness began with vomiting, drowsiness and temperature of 101°.

August 10, 1916. Since last note temperature has ranged between 101

and 98.8°. On physical examination the child appears to be prostrated, generally weak, no paralysis. Kernig on both sides, and reflexes present and equal.

Puncture performed by Dr. Hoch of Rosyln yesterday (August 9, 1916) at 96 hours. Cell count 220.

Note.—Child has been having convulsions described as epileptic in character, since 10 months of age. Total number of convulsions about 10. Patient did not develop paralysis.

August 30, 1916. Slight loss of weight, but up and about and very active. Showed no weakness or paralysis at any time.

Case 23.—D. B. Girl. Age 9 years. Sea Cliff, L. I.

August 6, 1916. Illness began with temperature of 102°, vomiting, malaise.

August 10, 1916. Vomiting has persisted since onset, temperature ranged between 98.6° and 102°. Child has been very drowsy at times hard to arouse. No weakness or paralysis has been detected.

Physical examination shows the eyes normal. There is a slight weakness of the facial muscles. Mouth: teeth in poor condition, many carious, and gums infected. Tonsils slightly congested. Heart: soft blowing systolic murmur at apex. Lungs: negative. Abdomen: negative. Extremities: no apparent weakness or paralysis. Knee jerks present, normal. Temperature 99.8°, pulse 96. Kernig sign on both sides. Child appears prostrated.

Puncture at 96 hours. Fluid clear, under slight pressure, 8 c.c. obtained. Cell count 140. Noguchi +, albumin +.

Note.—Patient's sister, aged 3 years, punctures yesterday (August 9, 1916). 220 cells, no paralysis.

Case 24.—W. E. Boy. Age 1 year 6 months. Smithtown, L. I.

August 10, 1916. Child taken sick, running a temperature of 101° to 102°.

August 17, 1916. Since the above date the child has been running a constant temperature of 101° to 102°, and has slept the greater part of this time. Vomited several times and complains of pain in epigastrium.

Physical examination showed temperature 102°, pulse 100. Eyes are equal. Mouth: teeth and tonsils in good condition. Heart and lungs negative. Abdomen: normal. Extremities: no weakness or paralysis. Knee jerks very active and equal. No Kernig sign.

Puncture.—Fluid under moderate pressure. Cells 320.

Discussion.—Cases 20 to 24 inclusive illustrate the most difficult of all types to recognize. The signs of central nervous system disease, are absent practically throughout and often when the lumbar puncture fluid shows a high cell count. Cases 21, 22 and 24, frequently the first indication of central nervous system disease is the paralysis occurring surprisingly in the course of a mild febrile upset. The

mechanism of the straggling type of case is probably similar to that of the dromedary.

SUDDEN ONSET GROUP

Case 25.—E. E. L. Girl. Age 3 years 10 months. Oyster Bay, L. I.

August 21, 1916. Suddenly at ten this morning seized with pain in back of neck. Continued to play until 12 o'clock, then gave in and began to be feverish. Became worse. 3 P.M. temperature 102.6°. 7.15 temperature 102.4°.

Physical examination showed a well-nourished child, yellow hair, brown eyes, incisor teeth separated. Patient presents acute febrile picture, with definite fine ataxic tremor on motion. Knee jerks are absent. Patient is apprehensive and nervous. There are no weaknesses.

Spinal fluid hazy, pressure normal, cells 2430. Given 15 c.c. of serum.

August 22, 1916. Attending physician thinks the patient slightly improved. Has had a fair night with 6 hours sleep. Bowels have not moved and no food has been taken since last visit. Physical examination shows stiffness and tenderness of the neck and spine, and a positive Kernig in each leg. There are no paralyses or weaknesses made out. Temperature is 102.2°.

Lumbar puncture.—20 c.c. of cloudy fluid under normal pressure, cell count 2220 leukocytes, and no red cells. The globulin reaction is very marked. Fehling reaction positive.

August 22, 1916. At 9.30 P.M. attending physician reports that patient has rather suddenly assumed an opisthotonos position. Temperature 103°. Face quite flushed, breathing somewhat rapid. 15 c.c. of serum together with 1½ c.c. of adrenalin chloride were given intraspinally. Cell count was not made.

August 24, 1916. Temperature is about 1° lower than on the previous day, but is still higher than it should be. Opisthotonos continues and paralysis of the right arm with weakness of the left. Cyanosis of the lips and face and evidence that the accessory respiratory muscles are involved.

Spinal puncture performed and 15 c.c. of serum together with 1½ c.c. of adrenalin chloride were given. Cell count 250.

August 25, 1916. At 10 A.M. condition is very poor. Temperature high, pulse rapid, appearance cyanotic. 2 c.c. of adrenalin chloride was given intraspinally. Died 11.30 A.M. of respiratory paralysis.

Discussion.—Here is an example of overwhelming cerebrospinal infection. At the time the patient was first seen no history could be obtained of symptoms pointing to any general infection preceding the attack on the meninges. Some months later, however, after the excitement and anguish of the moment had passed, the mother remembered that on the previous day the child had complained of feeling badly.

Case 26.—D. S. Girl. Age 14 years. Babylon, L. I.

August 21, 1916. Gone feeling in stomach.

August 22, 1916. Pain in her neck and right shoulder. Temperature 102°, pulse 130.

August 23, 1916. Slight pain in shoulder. Examination showed no paralysis. Left knee jerk less than right; right knee jerk present; irritable and slight stiffness in the neck. Catamenia, usually no symptoms.

Puncture at 48 hours. No increase in pressure, 504 cells.

September 3, 1916. Complete recovery. No paralysis.

Discussion.—It is a question whether the first complaint of "gone feeling in the stomach" represents the beginning of the disease or the beginning of central nervous system involvement. The early appearance of pain in the neck and shoulder suggests the latter. Consequently the case is grouped among those with "sudden onset." The high cell count at such an early stage would have made a paralysis not unexpected. None developed.

Case 27.—R. W. Boy. Age 1 year 2 months. Hempstead, L. I.

August 18, 1916. Parent states that nothing wrong was noticed with the child until several hours ago, when he felt unusually hot and somewhat irritable, crying a great deal, and suspected his neck being somewhat sore as he cried on movement of head. Attending physician, one hour ago, could not detect any physical abnormalities, aside from temperature of 103°, and slight rigidity of the neck.

Physical examination shows child lying in bed, drowsy and very hot to the touch. Cries on movement of the head or extension of the thighs. Mouth, tonsils and pharynx are negative. Heart 130, no murmurs. Lungs are normal. Abdomen is normal. Extremities: no muscular weakness, or paralysis detected. Temperature 103°. Reflexes: knee jerks are both present, equal and markedly exaggerated. Kernig moderate on both sides.

Puncture at six hours. Fluid clear under great pressure. About 20 c.c. obtained (flowed for a few seconds a constant stream). Cells 230.

August 31, 1916. No signs of paralysis noted. Temperature normal. Child up and about.

Discussion.—The first complaint of the child directed attention to the stiffness and tenderness of the neck and caused the parents to notice that he was feverish. Lumbar puncture within a few hours showed a marked meningeal involvement.

Case 28.—M. N. Girl. Age 3 years. Islip, L. I.

August 14, 1916. Child drowsy, twitched in sleep and vomited.

August 15, 1916. Knees and back hurt. Temperature 103.8°.

Physical examination was negative.

Puncture at 36 hours. Pressure moderately increased, 330 cells, 60 per cent. mononuclears.

September 1, 1916. Child now well. Never developed paralysis.

Discussion.—Child went to bed well but during the night vomited and twitched. The next day there were 330 cells in the spinal fluid. No history was obtained of previous indisposition.

Case 29.—W. H. Boy. Age 22 months. Huntington, L. I.

August 23, 1916. Taken sick at 1 P.M. No vomiting, no pain: Bowels loose, four movements. Markedly drowsy, apathetic, appetite gone. Temperature 103.5°. Positive Kernig on the left. Patellar reflexes slightly diminished on both sides.

Spinal fluid at 36 hours, shows slight increased pressure, cell count 70. No paralysis developed.

Discussion.—The looseness of the bowels at the time of the meningeal reaction is rather unusual. The drowsiness and positive Kernig point to central nervous system invasion, and the cell count confirms it.

Case 30.—L. F. Male. Age 23 years. Oyster Bay, L. I.

August 17, 1916. Complained of pain in the abdomen radiating to middle of back. In the evening it was in the middle of the back and in back of the neck.

August 18, 1916. Does not have pain in the abdomen. Has severe headache. After taking medicine prescribed by the doctor felt nausea and finally vomited. Patient constipated.

Physical examination showed the patient sitting up. Answers questions quickly. Neck stiff and painful. Knee jerks, both sides, present, slightly exaggerated. No evidence of paralysis.

Lumbar puncture at 36 hours. 15 c.c. of clear fluid under slight pressure. 15 c.c. of serum drawn off and serum given. Cell count 132. Globulin: Pandy ++++. Noguchi ++++. Ross-Jones ++++.

Discussion.—The patient was punctured about 36 hours after the onset of symptoms. A well-marked meningeal involvement was already present. The localized pain in the abdomen is a phenomenon which occurred several times in cases with no general systemic symptoms. It is somewhat hard to decide whether this symptom belongs to central nervous system involvement or to the digestive disturbance of a systemic phase of short duration.

Case 31.—K. McL. Boy. Age 18 months. Northport, L. I.

August 19, 1916. Sister has had the disease. Child in bed sleeping, with no history of disease other than slight diarrhea for two days. Constitutionally he has seemed well and is awakened from sleep for the purpose of examination and temperature. This child was well on going to bed after playing all day. At 1 A.M. the temperature is 105°F.

Physical examination shows normal eyes, ears, nose and throat, heart, lungs and abdomen. Neck and spine stiff and tender. The head will not flex upon the chest. Suspension by the head and buttocks causes

arching of the back and pain. Kernig is positive in both legs and no paralysis is made out in any part of the body. Reflexes normal.

Spinal puncture shows clear fluid under normal pressure with a moderate globulin test and 320 cells.

This patient was given serum and his further history is related in connection with that group of cases.

Discussion.—In this instance the mother objected to having the child awakened at one o'clock in the morning to have his temperature taken. The diagnostician of the Health Department insisted on the ground of the slight intestinal disturbance of the previous day and the fact that the sister was ill with frank poliomyelitis. This course was justified by the finding of the high temperature and high cell count. If this case had not been observed at this time, but the first observation had been made the following morning and the child found with high fever and meningeal irritation it would have been considered a typical example of what the English call "paralysis of the morning," having gone to bed well and waking up ill and would have been reported as a case of sudden onset, but fortunately the parents remembered the very slight intestinal upset of the previous two days which had not been sufficient to make the child stop playing. The meningeal invasion must have taken place at some time between six or seven in the evening and one o'clock in the morning.

MULTIPLE PUNCTURE GROUP

Case 32.—A. L. Male. Age 32 years. Oyster Bay, L. I.

August 21, 1916. Patient felt poorly.

August 22, 1916. He felt all right.

August 23, 1916. Felt feverish and somewhat "dopey."

August 24, 1916. Complains of headache, feverishness and slight stiffness of the neck. Temperature 102°. Patient is a large acromegalic type. Pharynx is congested and he has a slight cough. Heart and lungs are negative and there is no other explanation of the temperature. Knee jerks are present. Neck is slightly rigid. *Spinal fluid* is clear and shows no cells. Globulin +, and pressure 3 mm. of mercury. No history of vomiting or constipation.

August 25, 1916. Temperature 101°. Still has cough and complains of headache. Feels weak. Spinal puncture reveals no increase of pressure, fluid clear with no cells. Neck is distinctly stiff but not markedly so.

August 26, 1916. Temperature 100.4°. Neck more rigid. Did not sleep well last night, feels restless. There is considerable tremor of both hands, especially of the right side. No Kernig or clonus. Knee jerks still present. Spinal fluid is still clear, but shows 50 cells. Globulin again positive. 15 c.c. of serum given with 1½ c.c. of adrenalin chloride intraspinally. Taken to Locust Valley Hospital.

August 27, 1916. Running a slight temperature. 15 c.c. of serum administered.

August 29, 1916. Temperature normal. Patient feels well and would like to get up, but there is a slight though definite weakness of the left thigh and leg.

Discussion.—The patient was the father of two children who had the disease, in the same week, one of which was fatal. The case is interesting because it shows a dromedary type and the series of lumbar puncture demonstrate the very slow reaction of the meninges to the invasion of the disease. It is worth while noting that the first and second specimen of fluid had no cells but the globulin was increased.

Case 33.—J. M. Boy. Age 3 years. Glen Cove, L. I.

August 18, 1916. Slightly ill, continued so for two days. Apparently no temperature. Took his food and slept well. Had two loose movements and did not seem his usual self.

August 22, 1916. Showed rather an abrupt change with a rapid onset of fever and three or four attacks of vomiting. Temperature remained high; child seemed peevish and restless, but no appetite and bowels were constipated. At times he complained of pain on swallowing. There has been no cough, pain in chest or abdomen.

Physical examination shows a well-nourished, splendidly developed child. Eyes and ears normal. Throat shows large tonsils but no evidence of inflammation. The cervical glands are not enlarged or tender. The heart, lungs and abdomen are normal. There are no paralyses. Knee jerks cannot be done. Kernig sign is negative. The neck is stiff and tender, and back the same. Supporting child by head and buttocks causes arching of the spine and pain.

Lumbar puncture at 48 hours.—Shows 10 c.c. of clear fluid under normal pressure. Cell count 40. The globulin test shows a moderate reaction. Fehling's test is negative.

August 24, 1916. Patient distinctly better to-day. Temperature is going down but drowsiness still continues. There is no Kernig. Knee jerks are present and only slight stiffness of the neck. The child cries. There is left facial palsy observed for the first time. Cell count 190 at the bedside. Although this is a slight increase over the original count yet because of the facial paralysis which has developed and the low temperature it was deemed wise not to give him any serum.

August 25, 1916. Temperature is coming down. Child is brighter but still keeps very quiet. No further paralyses.

August 26, 1916. Temperature is still descending. No additional paralyses.

August 29, 1916. Temperature normal. Child sitting up and playing.

Discussion.—This case presents two days of general mild illness preceding a sharp aggravation of symptoms accompanied by stiff neck and tender

back. Spinal fluid withdrawn 48 hours after the onset of severe symptoms showed 40 cells; 48 hours later with the appearance of facial palsy a second puncture showed 190 cells.

Case 34.—L. G. Girl. Age 10 years. Oyster Bay, L. I.

August 18, 1916. Complained of sore throat, which is red. Temperature 99.4°.

August 19, 1916. Temperature 100° to 100.4°. Throat still red. Cervical lymph nodes enlarged. No vomiting. Appetite good. Bowels moved under catharsis. No spinal sign. Knee jerks absent. They were present yesterday. *Spinal fluid* at 24 hours is clear, pressure slightly increased, no cells. Globulin +.

August 20, 1916. Temperature normal. Patient apparently well. Temperature rose during the day to 100.4°.

August 21, 1916. Temperature normal. Later 99.2°. Headache began. No spinal sign. Knee jerks still absent. *Spinal fluid* at 48 hours. Fluid clear, pressure normal, cells 16. Globulin +.

August 30, 1916. Child quite normal, having no paralysis at any time and shows no loss of weight. Both knee jerks and ankle clonus have returned.

Discussion.—This is a very mild case of dromedary type in which the first puncture was done during the first hump. Note the positive globulin. Then followed a period of normal temperature, succeeded in turn by a second temperature rise accompanied by headache. At this time the spinal fluid showed small cell increase and positive globulin.

Case 35.—W. Z. Boy. Age 2 years. Great Neck, L. I.

August 12, 1916. Patient well until afternoon when he was feverish and listless. No vomiting.

Spinal Puncture.—Pressure normal, fluid clear and increased in amount. No cells. Globulin negative.

August 13, 1916. Same symptoms as yesterday. *Spinal puncture* at 30 hours. Fluid under moderate pressure, cell count 90. Child sent to Hospital at Roslyn.

August 31, 1916. Temperature 99.8°. Weakness of lumbar muscles with lateral curvature in the thoracic region to left. Slight spinal tenderness.

Discussion.—This is an instance of short course. Puncture was made a few hours after the onset of the symptoms, and showed a negative cell count and no globulin. Twenty-four hours after with the development of slight spinal signs the spinal fluid showed 90 cells. In this case there was rapid improvement and it was not until several weeks after the acute disease that slight weakness of the lumbar muscles was discovered. In this case the period of invasion of the meninges was indicated by the consecutive lumbar punctures.

Case 36.—G. L. Boy. Age 7 years. Hempstead, L. I.

August 15, 1916. Large, well-nourished boy. Teeth slightly wide. Began this A.M. Headache and temperature. Patient flushed and bright eyed, quiet, neck slightly stiff. Knee jerks ++.

Spinal fluid at 8½ hours. Clear, pressure normal, cells 3.7. Globulin ++.

August 16, 1916. Temperature 98.8°. Neck and back very slightly stiff and tender on stretch. Muscles and reflexes normal. Child looks well. Does not seem ill. Kernig negative.

Lumbar puncture at 32 hours shows 35 cells with clear fluid under no pressure. In view of the marked general involvement and low cell count it was decided that serum be not injected.

August 18, 1916. Patient much better, neck still a bit stiff. Knee jerks ++.

September 1, 1916. At Garden City Hospital. Temperature 98°. Up and about. No weakness or paralysis. No spinal tenderness.

Discussion.—This case was a very short dromedary type. The first puncture done within several hours of the onset of symptoms showed 3.7 cells and a strongly positive globulin and indication of a beginning disturbance of the meninges. Twenty-four hours later there was a definite cellular reaction in the spinal fluid. In the meantime the patient became much better but the spinal tenderness was more marked. The patient cleared up rapidly without any paralysis. In this case the second spinal puncture was probably made in the period of the second phase although clinically this stage of the disease was unimportant.

Case 37.—T. W. Girl. Age 15 months. North Hempstead, L. I.

August 19, 1916. Pale, sick appearing, fretful girl. Temperature 102° to 104°.

August 20, 1916. *Spinal fluid* at 48 hours. Clear, under increased pressure. Withdrew about 10 c.c. Cells 70. Onset the day before was noticed about 7.30 A.M. when the patient became drowsy and refused the bottle and later vomited. Vomited four times during the day. Has not vomited to-day. Bowels all right. Knee jerks present. Neck not stiff. No paralyses. Weakness in the knees.

August 21, 1916. Temperature 100°. *Spinal puncture* at 72 hours. Cell count 80. Appetite has returned. Bowels move normally. Slept well last night, and is quite cheerful and bright. Slight stiffness of neck still present.

August 23, 1916. Doctor reports that patient is sitting up with normal temperature. No paralysis.

August 25, 1916. Doctor reports that patient is sitting up and seems perfectly well.

Discussion.—In this instance it is difficult to determine whether the rather sudden onset represents systemic invasion or meningeal invasion.

The first lumbar puncture was done 48 hours after the original onset of the symptoms. The second puncture following the first after 24 hours showed only very slight increase in cells. There was no continuance of the temperature and the stiff neck. This was a mild infection throughout. The advance in the cerebrospinal space was never very great.

CHAPTER VII

SYMPTOMS

In its early hours the clinical course of acute poliomyelitis resembles in general that of all the acute infectious diseases of childhood. Fever is almost invariably present with its attendant restlessness and dry-mouthed discomfort. The picture in the individual case is colored by symptoms depending on which particular set of organs is chiefly involved. Perhaps the most usual form is disturbance of the gastrointestinal tract simulating a simple "summer diarrhœa"; vomiting is likewise a very frequent symptom. But tonsillar and pharyngeal inflammation or upper respiratory tract symptoms are not uncommon. Still, even in the midst of an epidemic, it is hard at first to realize that the flushed, hot, restless patient is already in the grip of the insidious disease that may cripple for life if it does not kill. Yet those symptoms do not represent a prodromal stage, they are the expression of the fully developed infection. It is impossible to determine at this period of the disease whether the subsequent course will be dromedary or straggling in type, or whether it will terminate at the end of the systemic phase.

Notwithstanding the foregoing remarks, however, there seems to be little doubt in the minds of those who have seen much of the earliest hours of the disease that a very definite and characteristic clinical picture presents itself. But it is difficult by descriptive method to transfer an adequate impression of the subtile and striking difference between the onset hours of infantile paralysis and those of any other of the acute infectious diseases of childhood. To say that the temperature is elevated, often as high as 103° or 104°, and that the child is flushed and miserable; that vomiting often occurs and that drowsiness supervenes, does not offer sufficiently distinguishing evidence of the special type of infection. Nevertheless,

in acute poliomyelitis, this common symptom complex is shot through with delicate manifestations that are unmistakably specific, but which must still be viewed as clinical impressions—those helpful though indefinite aids in diagnosis.

Now when infantile paralysis becomes epidemic in a locality which has been previously free from its presence, the physicians in that territory soon appreciate this difference from the usual illnesses of children. Without exception, all speak of the peculiar expression about the eyes. For, besides a glazed porcelain quality of the sclera and cornea, and the not infrequent puffiness of the circumorbital tissues, there is a look of mingled apprehension and resentfulness, quite unlike the alert, bright and shining eye of other fevers. The psychic change

FIG. 14.—(Reproduced from the Monograph.)

NOTE.—Separation of upper central incisor teeth.

responsible for this look finds further expression in a characteristically annoyed shrugging of the shoulder which occurs when the child is touched or simply spoken to. Indeed there is frequently a snarling whine of resentment which is synchronous with this gesture of discontent.

There is, besides, another smaller number of cases that present certain perfectly definite signs of early disturbance of the central nervous system. These are the cases of overwhelming infection, where for example, after 6 or 8 hours of illness the spinal fluid shows 1500 to 2500 cells per c.mm. Again the temperature is high and the usual picture of a sick feverish child appears. But, in addition, there are other striking phenomena. The child is restless, breathes rapidly and seems to

be busily and actively resisting some incomprehensible disturbance of its usual comfort. In these instances, the irritability and resentful manner are not marked, but the whole organism seems to be composed of tensely drawn wires—a universal overstimulation. This pressor state of the nervous system is so marked that a sort of impulsive ataxic tremor is present in every motion, especially when that motion has intent. Probably of similar nature to these irritative signs are the muscular twitchings described in the Monograph and recently emphasized by Dollivar. The ataxic tremor may be present in the less fulminating cases, after the invasion of the central nervous system has taken place. It is interesting to recall at this point that the very earliest symptoms in the monkey subject of experimental poliomyelitis are not at all unlike those just described, for the animal becomes highly excitable and seems to develop the same state of intense excitability of the entire nervous system. Usually a few cases are met with whose profound stupor masks all other signs and symptoms so that no specific clinical impression is produced.

One physical sign of great importance, however, must be mentioned especially at this time. It depends upon the fact that in acute poliomyelitis any manipulation which brings about anterior bending of the spine causes pain and, therefore, is resisted by the patient. The resulting stiffening of the body has generally been loosely described as "stiff neck" or "Kernig's sign," but there is an essential difference between these reflex phenomena of meningeal irritation and the voluntary protection rigidity assumed by the patient with poliomyelitis to prevent anterior flexion of the spine. This conscious effort is often carried to a moderate degree of opisthotonos, and is the cause of the unwillingness of children with this disease to be picked up and handled even by the mother. Attention was called to this sign in the Monograph and we refer to it here as the "spine sign." This phenomenon may be present before any invasion of the meninges has occurred as shown by negative spinal findings. We have suggested as an explanation for the sign that in flexing the spine anteriorly the intervertebral spinal ganglia are pulled upon. If it be recalled that the virus

has been found experimentally in the posterior spinal ganglia (see p. 25) before meningeal invasion this suggestion for the mechanism of the spine sign receives some support. It is conceivable that the ganglia being the seat of inflammatory reaction may be unduly sensitive.

If the disease be in the earliest hours a child is found lying upon the sofa or curled up in a chair. Its usual spirited activity has gone, and, quietly without complaining of any special distress, it simply ceases to move about or play as before. It prefers to lie down and keep silent. At this time the temperature may be elevated to a moderate degree—100 or 101. Not infrequently there is a definite puffiness about the eyes. Physical examination reveals nothing abnormal or at the most a slight redness of the throat, and coated tongue. In a few cases at this period slight tenderness may be found on bending the neck forward, or by forcing the Kernig manipulation to the limit, for both these procedures cause anterior spinal flexion. But the significant thing about the clinical picture at this stage is the absence of any sign of central nervous system involvement.

Obviously it is important to detect when the invasion of the meninges takes place or, in other words, when the systemic phase passes over into the meningeal. Sudden and definite increase in the spine sign may indicate that this extension has occurred. Rapidly developing intense headache, or disturbances of tendon reflexes may also mark it. But evidence has been gathered by spinal fluid examination to show that meningeal reaction to the disease may be actively under way when there is no sign or symptom to indicate it. (See Cases 11, 14, and 21.) This phenomenon calls to mind those instances of cerebrospinal syphilis, in which an apparently healthy man may have pathological changes in his spinal fluid as extreme as those seen in tabes or fully developed paresis.

Heretofore it has been the habit of physicians to wait for a confirmatory paralysis to establish the diagnosis of poliomyelitis. Such delay, of course, is not now permissible, since the hopeful possibilities offered by serum therapy have arisen. Consequently it is necessary to recognize the disease

at the earliest possible moment, preferably while it is still in the general systemic phase. Clinical observation, especially in epidemic time, can go far toward making the diagnosis, but with an isolated case it is not by any means secure. Examination of the spinal fluid, however, offers a criterion of great value. In several instances where lumbar punctures were made in the early hours of the systemic phase and repeated at 6- to 10- or 12-hour intervals, it was possible to observe the reaction of the meninges to the invasion of the virus cases. This will be discussed more fully in the chapter on blood and spinal fluid.

These considerations clearly bring up the question as to the propriety of making repeated punctures. Now during the early and middle part of the epidemic last summer, it was believed that serum of recovered cases was only valuable if injected intraspinally. It was essential, furthermore, to introduce the serum as soon as possible after meningeal invasion took place. This requirement became at once the justification for making multiple punctures, because the spinal fluid alone presented, absolute evidence that this event had occurred. It is possible though that in not a few cases the appearance or intensification of the spine sign may prove almost as delicate and reliable a test of meningeal involvement as a pathological spinal fluid.

Anticipating a point of treatment just here it might be stated that since the immune serum possesses specific neutralizing power over the virus, its administration during the stage of systemic infection is indicated, not by way of meninges alone, but by way of the blood. This view is not wholly theoretical but has received definite support from the recent work of Amoss and Chesney,[45] which indicates that, besides the intraspinal use of serum, intravenous or subcutaneous injection has additional therapuetic value.

Under this new condition of effective administration the earlier in the disease the serum is given the better. Hence, the necessity is no longer that of waiting for the moment of meningeal invasion but becomes that of recognizing the systemic phase of the disease as promptly as may be.

It may be well to state in this connection that at this period, in mild cases, differentiation from trivial digestive disorders, or light infection of upper respiratory tract is impossible. In epidemic times, every such case should be viewed with suspicion and watched closely.

When the disease is more intense, the child develops the glazed eye expression described elsewhere, and looks much more ill. It is quite common to see patients at this time so severely intoxicated as to present almost the picture of a very severe case of pneumonia, and yet have no trace of meningitis or other central nervous system involvement.

Such a child may be found lying on its back, with thighs slightly flexed and everted in a frog-like manner, and the head usually rotated to one side. The eyes are partly or wholly closed and there is a peculiar, tired, wilted expression. Not infrequently, the chin is pointed upward a little, indicating a small degree of retraction. From this drowsy or almost sleeping condition, the patient can be roused suddenly, often by the gentlest touch or manipulation of an extremity. Very frequently when the leg is lifted only a few inches from the bed, an expression of annoyance, rather than distress, crosses the face, and if the leg be the paralyzed one, the child often tries to free it from the examiner's hands by twisting the trunk and shoulders. This procedure is a surprisingly common one and is usually accompanied by a pettish, fretful, rather bored look and whine. But when the examiner stands back from the bed, the patient lapses almost at once into the drowsy state. In contrast to these cases are those of a more sthenic nature with evidently greater meningeal irritation. These children are almost always found lying on their sides with their heads drawn well back and their knees and thighs flexed, a typical meningitis posture. Occasionally a true opisthotonos appears. One such patient could not be made to lie on his back, evidently because the flat line of the mattress prevented the slight degree of opisthothonos which made him comfortable; but when a pillow was doubled up under the lower dorsal and lumbar region so that an opisthotonos was induced by gravity acting on hips and shoulders, the child promptly went to sleep in the

dorsal position. Such cases also are apt to have the drowsy, wilted look. Much more rarely, the child is wide-eyed and has an anxious, apprehensive, rather frightened expression. Many times these patients do not wait to be touched before objecting, but cry out even when the nurse or doctor approaches the bed; and it is surprising how keenly the little patients seem to determine whether or not an approaching person is coming to perform some service which necessitates manipulation. In these cases one is amazed at the ingenuity and activity with which the child, using what muscles he has, braces and turns and twists to escape painful positions. Indeed, in two instances where both legs, both arms, back, anterior and posterior neck muscles were paralyzed, the hopeless attempt at defense was limited to wagging the head from side to side and feebly whining.

From this point several developments in the course of the disease are possible. The condition may clear up rapidly and permanently in 12 to 24 hours or the curious "dromedary" type may eventuate. There may be a continuous course of increasing intensity ushering in meningeal and nervous invasion.

There are certain more general signs and symptoms which are common to such large numbers of cases that they may well be mentioned separately. Pain is a very frequent symptom, often spontaneous in the form of headache or aching bones and muscles. Great tenderness of muscles may appear and be so intense as to dominate the picture for several weeks. Indeed this muscle tenderness may be so keen and persistent that it is the only thing which keeps an otherwise well child flat in bed.

The superficial lymph nodes are always palpable and often enlarged and the pharynx and tonsils very frequently red and congested. Many cases show a peculiar weakness of the anterior neck muscles, apparently not a true paralysis, which can be demonstrated by lifting the shoulders of the patient off the bed. The head then hangs back limply.

The reflexes are most irregular in their behavior. There may be no change whatever, or there may be any degree of abnormality from absence of tendon reflex to the most extreme exaggeration. Not infrequently one knee jerk may be active and the other diminished or absent. These changes are usually

present only after meningeal invasion has taken place. In many instances loss of a tendon reflex is the forerunner of paralysis. It is a fairly common occurrence to see the knee jerks or ankle jerks disappear for a day or two and then return and the patient recover completely without paralysis.

During the first or systemic phase, especially if gastro-intestinal symptoms dominate the picture diarrhœa is very common. But one of the most striking facts in the whole disease is the almost universal occurrence of constipation during the second or nervous system phase.

The temperature curve of the disease is usually of short duration and falls rapidly through 24 to 48 hours. Not infrequently, however, irregular or prolonged curves are met with.

CHAPTER VIII

CLINICAL PATHOLOGY

The Blood.—The blood in acute poliomyelitis shows a constant change. While the previously accepted view was that a leukopenia was the rule, the investigations of LaFetra and those reported in the Monograph indicate that a leukocytosis is the more correct finding. The total white cell count in the preparalytic stage shows a constant and marked elevation of from 15,000 to 25,000. In the differential counts a definite polynucleosis appeared. The increase of polynuclears averages 10 to 15 per cent. above normal and there is an average diminution of lymphocytes of 15 to 20 per cent.

The Cerebrospinal Fluid.—In acute poliomyelitis the spinal fluid presents different conditions depending on the stage of the disease at which it is examined. If the puncture be made in the very early hours after a child shows symptoms of illness the fluid is clear, and the pressure often increased. Furthermore, the volume of fluid seems to be greater than normal. Microscopic examination, however, fails to reveal the presence of any cellular elements. There may be a very faint (o—+) reaction for globulin, but this is not constant. If no further symptoms develop and the child recovers after a day or two, it is obvious that such a spinal fluid has been of no diagnostic value. Yet if such a case be in the family where one or two other members are stricken with paralysis and have been through a similar systematic phase as that just referred to, we are led to assume that we have been dealing with a case of poliomyelitis that has terminated at the end of the systemic phase or first hump of a dromedary type (abortive). There has been no penetration of the meninges by the virus under these circumstances and the spinal fluid shows no pathological changes unless the increased amount and pressure be looked upon as pathological.

Now when the patient, after the interval of a dromedary

course, or following the straggling period of the other type suddenly develops increased stiffness of the neck or very severe headache with renewed temperature, pathological changes in the fluid may be expected. A second puncture done at this time—possibly 12 hours or more after the first—provides a fluid whose pressure may be definitely less than before and whose clearness may or may not be impaired. Is it rarely opalescent or turbid. Here at once is a gross point of difference from the fluid of epidemic cerebrospinal meningitis. Zingher has described a "ground glass" appearance of the fluid due, he says, to the increase of cells. The present author has not seen that this phenomenon differs from the appearance always ascribed to an excesive white cell content of spinal fluid. On microscopial examination the cell content is found to be increased. Anything over 10 cells to the cubic millimeter is pathological, and the count may run as high as 2500 per c.mm. At the earliest period of meningeal involvement the cells are largely of a multilobed type resembling and usually spoken of as polynuclears. They are not, however, the polymorphonulcear neutrophiles of the blood, but more probably the wandering tissue cells or clasmatocytes of Marchand. Very rapidly these cells give place to small lymphocyte types so that by the end of 24 to 36 hours, these latter cells represent over 90 per cent. of the total. The globulin content now begins to rise and is easily demonstrable by the methods of Noguchi, Pandy or Ross Jones. The Wassermann reaction is regularly negative but the colloidal gold test of Lange shows almost constantly a weak luetic type of curve. During the following days there is a gradual descent in the number of cells in the fluid and a slight rise in the globulin content.

Generally speaking, the highest cell counts appeared in those cases in which the spine sign was most intense. Undoubtedly in some of these instances there was a combination of factors in the production of the extreme stiffness of the neck. On the one hand, the voluntary effort, as already discussed, played a part, and on the other, the element of true reflex spasm occasioned by the extreme meningeal irritation was added. Examples of this type are cases E. E. L. No. 25 and R. N. No. 32.

The former presenting extreme neck stiffness 7 hours after her first complaint of feeling badly had 2430 cells per c.mm.; the latter having gone to bed apparently well, had been restless in the night and had awakened in the morning with marked rigidity of the neck and 2000 cells per c.mm. Both these children were treated promptly and repeatedly intraspinally with serum. Case 28 died, and Case 32 survived with very extensive paralyses which at the present writing, 7 months after the attack, are improving remarkably well.

With very few exceptions the intensity of the spine sign and the cell count in the spinal fluid bore a fairly close relationship so that we came to feel that it was possible roughly to prognosticate the number of cells that would be found in a given case after testing the cervical stiffness. Nevertheless, there were some examples of quite opposite character, those with high cell counts and no signs of spinal irritation and others presenting the reverse condition.

There is no doubt as was pointed out in the monograph, that fluid drawn later than 24 to 36 hours after the period of meningeal invasion provides only diagnostic criteria. It is possible, however, that spinal fluid taken in the first 12 to 18 hours following meningeal involvement may have some prognostic significance depending upon the number of cells per c.mm. Whatever indications may be suggested by differences in cell counts lie at the extremes, rather than within the more average ranges. Thus cases with cell counts below 100 rarely developed paralysis while cases with counts of 500 or over frequently did. Practically every fatal case showed more than 600 or 1000 cells per c.mm. These figures apply to fluids taken within a few hours after the occurrence of meningeal invasion as determined by the history and clinical observation.

There is one group of cases to which, in this connection, especial attention should be called. Patients of this group presented a clinical picture of varying severity. Some were profoundly toxic, drowsy or indeed comatose. Spinal fluid examinations in this group always showed a surprisingly low cell count, usually below 100 per c.mm. The subsequent course in all of them was striking because of its mildness. An isolated

facial paralysis usually transient was almost the rule in this series (Case 33, Diagnostic Series).

To sum up, it may be said then that spinal fluid taken during the first hump of the dromedary type, or the early part of the straggling course, shows no cellular increase and little or no globulin. The pressure and quantity, however, may be noticeably greater than normal. After meningeal invasion has

FIG. 15.—Facial paralysis in case with profound stupor. (Reproduced from the Monograph.)

occurred, the pressure is definitely lower and cellular elements appear. In general cases with cell counts below 100 per cubic millimeter within the first 12 to 18 hours are less apt to develop a paralysis than are cases with counts of 500 or more. The exception to the first group are those cases which have an isolated facial weakness. By making multiple punctures (at 10 to 12-hour intervals), it is possible to detect the time of men-

ingeal invasion. The puncture is most conveniently done when the child is lying on the right side with knees drawn up and head down so that the spine is flexed well forward. With young children cocaine is not necessary but the patient must be firmly held to prevent sudden twistings of the body while the needle is in place. A microscope and counting chamber should be in readiness at the bedside so that a count may be made while the needle is left in the spinal canal. During the count the obturator of the needle should be reinserted to check the flow of the spinal fluid. In the early hours of the disease the patient experiences much greater physical discomfort from the anterior flexion of the spine necessary to separate the spinous processes than from the introduction of the needle itself.

CHAPTER IX

THE PARALYSES

It is not profitable to discuss here in detail the relative frequency with which various muscles are paralyzed. The pathological process may involve any part of the central nerve tissues so that the neurological manifestations are multiform. The degree of nervous disturbance may vary from the mildest meningeal inflammation, giving signs of irritability, spine sign, and increased cells in the fluid, to a widespread destruction of the gray matter of the cord, causing rapidly advancing paralysis and death from failure of the anterior horn cells governing the muscles of respiration. Between these two extremes a great variety of conditions appear. The clinical signs of muscle weakness depend upon the pathological process but they do not represent with any accuracy the extent of the lesions. For at autopsy there is often found much more extensive disease of the cord than was indicated in life by weakened musculature. Frequently there is a slight weakness of the legs so that the child seems to prefer to crawl about instead of walk. This may last for a few hours and then disappear. There may be, on the other hand, definite transient paralysis of an arm or leg lasting from a few minutes to half a day or more. Or there may be a complete flaccid paralysis of one or more extremities, neck or back, which persists for a time and disappears or remains as a permanent disability. Much more rare are the hemiplegic and spastic forms of paralysis, due to upper motor neurone involvement. These are the true "encephalitic" types described by Strumpell. In comparing this and the more usual form of the malady he says "in both diseases the chief seat of the lesion is in the gray matter, in one case in the gray matter of the anterior horns, and in the other in the corresponding portion of the cerebrum, the cortex." Besides these paralytic manifestations there are

met certain other forms of the disease. Among these may be mentioned the rather rare multiple-neuritic in which a continuance of pain along the course of the peripheral nerves is intense. Occasionally also one sees patients who have a marked ataxia and stagger like cases with cerebellar disease of other origin. Psychic disturbances of various sorts are seen frequently. Convulsions may occur, or profound stupor often resembling some types of tuberculous meningitis. In this type of case now and then a faint twitching or tremor passes over an extremity or the whole side. Yet, despite the coma-like condition, the patient can be rather easily roused by handling or prodding. There is almost immediate response and objection in the manner which has been so often seen in the other cases of this extraordinary disease, a displeased, irritated whine, and a vexed shrugging movement of the shoulder forward and upward, conveying quite distinctly the child's wish to be let alone. Other cases of this kind may show a more stuporous condition with partly closed eyelids beneath which moves a slowly rolling eyeball. These individuals may or may not have retraction of the head, and lie prostrated and somnolent. Still other patients behave as though heavily drugged, and carry out sharp commands by slow, lazy, intensely apathetic motions.

As a rule, the stupor clears with considerable rapidity, after a duration of from three to six days. In one instance, the patient after four days awoke as though from sleep, looked about in a bewildered fashion and then said she wanted to go home. Other cases regain normal mental condition more slowly, but the process occupies only a few hours. Occasionally prolonged clouding of the sensorium is seen as in case J. L., No. 29 (Treatment Series), where the patient remained comatose or stuporous for many days. Frequently children who recover present a highly excitable and nervous condition for weeks after the acute attack is passed and they are again up and about apparently as well as ever. Emotional instability shown by purposeless and alternate weeping and giggling is also not infrequently seen.

The accompanying chart shows the days upon which paraly-

sis appears. Obviously the second day is that on which most of the cases become paralyzed.

One of the most impressive things about the paralysis is its insidious and unexpected advent. A child goes to bed well with strong and active limbs to waken with a paralyzed member. In many cases there is no warning of the approaching weakness and the patient seems unaware that power has gone.

FIG. 16.—(Reproduced from the Monograph.)

Such a child lies quietly in bed, often not acutely ill for the fever may be passing, and when asked to move an arm or leg fails to respond, silently, without remark of astonishment. At other times there may be some premonitory indication of approaching paralysis. Slight muscular weakness or involuntary twitchings, or the loss of a tendon reflex often precede the final crippling. As a rule, however, the paralytic stroke is sudden and complete, the initial paralysis being final in its extent. A

certain number of cases show a progressive involvement of muscles. Thus the weakness may begin in part of one or another extremity, extend then to the whole of that limb and then on to another arm or leg. Practically all cases which go on to fatal termination belong to this progressive group.

It is not always easy, especially in very young children, to recognize the presence of a paralyzed muscle or group of muscles. Of course, complete flaccid paralysis of a whole extremity is obvious. But an isolated deltoid weakness, for example, or failure of the outward or inward rotators of the thigh may often escape detection. One most important and frequent oversight on the physicians's part is failure to recognize weakness or paralysis of the intrinsic muscles of the back.

Children are very quick to circumvent a muscular incapacity of one group of muscles by substituting makeshift motions to attain a desired end through the use of other groups of muscles not usually called upon for the particular purpose in view. Thus if the biceps and supinator longus are out of commission and the child wishes to flex the forearm upon the arm, he will accomplish the desired motion by swinging the whole extremity forward and upward so that the forearm is flung up into the flexed position. Then he will hold it there with his other hand. Or the same motion may be more slowly carried out by crawling with the fingers up over the front of the body and clinging with them to the bedclothes.

In order to detect whether or not a given muscle or group is paralyzed it is necessary to put the muscle to be tested in such a position that it must work against gravity. For by slight change in position a child will succeed in having the weight of an extremity accomplish the desired flexion or extension which the paralyzed muscles can no longer bring about. With younger children who cannot carry out commands, it is sometimes necessary to prod the skin slightly with a sharp object in order to make them attempt to move.

Following a rapidly advancing paralysis of arms or legs, signs of embarrassment of the muscles of respiration begin to make their appearance. A very small number of cases seem to have direct involvement of the medullary respiratory center and

seem to die from rapid exhaustion of this center although the muscles of respiration are still operating. In either case the picture is almost the same and constitutes one of the most distressing spectacles in the whole of clinical medicine.

A striking feature of the fatal cases is the condition of the sensorium. There is a peculiar, vivid alertness of the mental state of these patients. The frequent condition of drowsiness seen in the earlier stages of the disease gives place to apprehension and psychic activity.

With the onset of respiratory difficulty, it seems almost as if the children were suddenly awakened and made to realize the struggle before them. Little children seem to age in a few hours. One sees a heedless, careless, sleepy child become all at once wide-awake, high-strung, alert to the matter in hand, and this is, breathing. The whole mind and body appear to be concentrated on respiration. Respiration becomes an active, voluntary process, and every breath represents hard work. The child gives the impression of one who has a fight on his hands, and who knows perfectly how to manage it. All he wants is to be left alone, not to be interfered with, to be allowed to carry out his fight on his own lines. Instinctively he husbands his strength, refuses food, and speaks, when speech is necessary, quietly and with few words. One little child of four, so helplessly paralyzed that she was unable to move, but with a mind that seemed to take in the whole situation, said to the nurse clearly but rather abruptly between her hard-taken breaths, "My arm hurts"; "Turn me over"; "Scratch my nostril"; and then when the doctor approached, "Let me alone, doctor!" "Don't touch my chest." Pressure on the chest, tight neck bands, anything that obstructs easy respiration is immediately resented. The child demands constant attention, is irritated unless everything is done exactly as he wishes it, and often shows an instinctive appreciation for some especially efficient nurse. He is nervous, fearful, and dreads being left alone. The mouth becomes filled with frothy saliva which the child is unable to swallow, so he collects it between his lips and waits for the nurse to wipe it away. He likes to have his lips wet with cold water, but rarely attempts to take it into his mouth, for he

knows he cannot swallow it. During the whole course it is remarkable that cyanosis is absent. There is a little bluish tingeing of the lips and tongue, but much more distinctive is the pallor, which is sometimes striking. Sweating is profuse. Then, as respiration gets weaker, the mind becomes dull, and with the occasional return of a lucid interval, he gradually drifts into unconsciousness. An hour or more later respiration ceases. This peculiarly alert, keen mental state has been much less noticeable in small babies. They tend to be dull and drowsy most of the time; but in the older children this alertness has been such a characteristic feature of the fatal cases, that it is preferable to find a child in a stuporous condition, rather than with a mind whose nervous acuity seems due to a perception of impending danger.

It should be clearly appreciated, however, that many cases may show some interference with respiration and still not go on to a fatal termination. For those anxious hours of suspense occasioned by these instances there is a gratifying relief in the return of increasing depth and sufficiency of the breathing. Furthermore, it seems to be true that death in poliomyelitis is invariably the result of failure of the respiratory mechanism and not to toxæmia.

CHAPTER X

PROGNOSIS

The problem of prognosis in acute poliomyelitis involves several considerations: (1) What is the mortality? (2) Will paralysis appear? (3) Will an initial paralysis advance? (4) Will the paralysis be permanent?

In regard to the first question it may be said that mortality statistics are somewhat misleading. Until a very short time ago when the diagnosis of the disease was determined by the appearance of paralysis, statistics showed that approximately 10 to 15 per cent. of the cases were fatal. If, however, in the light of our present knowledge mortality be figured on the basis of all cases whether paralyzed or not, the percentage should fall. This would be true because it is only cases which develop paralysis that die. In the recent New York epidemic the mortality rate ran as high as 27 per cent. This figure was based on all cases accepted by the Department and these include a very much larger number of non-paralyzed cases than have been included in such statistics in any previous recorded epidemic. Consequently, notwithstanding the introduction of large numbers of non-paralyzed cases into the total, the death rate was higher than it has ever been before. There can be no doubt, therefore, that the exaggerated death rate, and the great number of paralyzed cases, indicated an extremely high virulence of the infecting agent in the recent epidemic. But no accurate figure for mortality in poliomyelitis can be established until diagnosis of non-paralyzed cases becomes as definite as it is in the smaller paralyzed group. In acute poliomyelitis there is a peculiar element of chance not present in other general infections; namely, the accident of the lesion destroying simultaneously the phrenic and intercostal centers, an accident which is invariably fatal. Unfortunately, there is no way of knowing where the lesion will occur, or if an existing lesion will advance.

Flaccid legs, arms or facial muscles point only to the cord segment most seriously injured when the case is first observed, and form no criterion of the extent or subsequent behavior of the lesion. Anterior horn cells that lie immediately outside the zone involved by the pathological process may continue to function properly, so that the proximity of the lesion to the phrenic and intercostal centers does not necessarily make the outlook worse. This and the fact that in most cases the initial lesion in the cord is the final one, and rarely advances, is perhaps the most encouraging knowledge that we command in attempting to make a prognosis as to life; for, as was pointed out in the section on paralysis, death in uncomplicated poliomyelitis invariably results from failure of the muscles of respiration. In other infectious diseases where death has been considered to depend upon toxæmia, mortality statistics represent more nearly an average failure of human resistance, affected less, perhaps, by the element of chance.

At the bedside of a given case, however, there are certain phenomena which seem to have some vague prognostic significance. Our experience has been that the profoundly stuporous cases usually get well. Increasing alertness and apprehension on the part of the child with an existing paralysis is of graver significance. Prognosis for life is markedly less good in older patients particularly of the type described in the chapter on Etiology.

When a child becomes acutely ill during an epidemic of poliomyelitis, so that the diagnosis is practically assured, the question at once arises whether paralysis will appear or not. In the presence of such a problem there is a distinct sense of obscured vision, because there seems to be no relationship between the severity of the symptoms in the systemic phase (first hump of dromedary type) and the accident of meningeal invasion. In some cases it has been possible to recognize almost the moment of occurrence of that event by repeating the lumbar puncture as already described.

If no evidence of meningeal irritation is found criticism is naturally leveled at the procedure of multiple puncture. For it is unfortunately still true that, without evidence of

central nervous system involvement, either through spinal fluid changes or paralysis, there is no incontrovertible proof of the correctness of diagnosis.

The spinal fluid, contrary to the opinion usually held, offers undoubtedly some prognostic suggestions. There are a sufficiently large number of observations to indicate that cases which show cell counts of less than 100 per c.mm. during the first 12 to 18 hours rarely develop muscular weakness, or at the most a transient facial paresis. Furthermore, cases having cell counts of 200 to 500 very frequently develop paralysis of the severer sort. With few exceptions the fatal cases showed counts of over 700 or a thousand.

Exceptions to these general statements occur. For example, a certain number of cases with cell counts of 150 to 300 per c.mm. escape paralysis. But there are remarkably few examples of paralysis in cases showing spinal fluid cell counts below 100 per c.mm. in the first 12 to 18 hours. Our experience last summer fully agreed with that stated in the monograph that after 24 to 36 hours the spinal fluid had no prognostic value.

Sometimes warning of approaching paralysis may be recognized in certain clinical signs. Occasionally there is increased pain in the extremity, although subjective indications are slight and infrequent. Loss of tendon reflex is a far commoner occurrence and often spasmodic muscular twitchings precede the loss of power. Both these signs, however, may occur without subsequent paralysis. There are no signs which indicate whether or not an existing paralysis will advance. All that can be said on this point is that as a rule the initial involvement is the final one. Usually if no additional muscle weakness appears within 6 to 12 hours of the first paralysis there is small chance of any further involvement. In a very few instances there has been a remarkable delay in the initial appearance of paralysis after onset of meningeal involvement as shown by spinal fluid examination (Cases 17 and 22 of Treatment Series). These are numerous enough, however, to make one apprehensive of a possible paralysis until the seventh or eighth day.

The final question in prognosis can be answered rather

more definitely by statistics than any of the others. With the advancing knowledge of the disease has come the satisfactory realization that there is a strong tendency for the weaknesses or paralyses to improve. Wickman reports on 530 cases analyzed 1 to 1½ years after the acute attack. Of these 56 per cent. were paralyzed and 44 per cent. were cured. The Massachusetts records show a much lower percentage (16.7 per cent.) of complete recoveries. It is too early yet to study the recent epidemic from this point of view. But all who have worked with the disease have been struck with the remarkable early return of power in badly paralyzed muscles and the full recovery of partial cripplings. Even after many months unlooked-for improvements may cheer the patient spirits of the convalescent and the family.

CHAPTER XI

TREATMENT

Prophylaxis.—If it be accepted that acute poliomyelitis is spread by human contact, isolation of the patient is the essential point from which to start an effective quarantine. The disease should be managed like every other acute contagious infection. There is still some difference of opinion over the question of proper duration of quarantine, but there can be none concerning the necessity. Furthermore, a quarantine which covers only the paralyzed individuals is incomplete. For when the great number of children who roam about suffering from the mild form of the disease is considered, the inadequacy of a quarantine for paralyzed cases alone becomes apparent. In addition to these, moreover, are the unknown number of carriers among healthy individuals and convalescents. In this relation the recent work of Amoss and Taylor on neutralizing bodies found in the nasal secretion of human beings is of particular interest. Although their experiments as reported do not cover a very large series of individuals, nevertheless the indication from them is that the neutralizing bodies in this position form a first line of defense. This has a bearing on the question of local prophylactic treatment which has been so much discussed in the past. The problem can, in the light of this new knowledge, be more intelligently discussed. The obvious purpose of local prophylactic treatment is to reduce the number of, or perhaps remove entirely the poliomyelitis organisms from the nasal mucosa. To accomplish this by mechanical means alone is unpromising. Hence, antiseptic chemicals have been added to the fluids sprayed or douched into the nose. Now that we have learned that the nasal secretions are themselves destructive to the virus, we should aim to conserve them.

Whether their action is best promoted by no interference, or by the gentle impetus to increased secretion afforded by bland saline and alkaline fluids, may be still regarded as an open question. But it would now appear to be patent that severe measures are contra-indicated, not only on general clinical grounds, but also from the standpoint of local protective action. Arguing from analogy to other acute contagious diseases, it is highly probable that the case of infantile paralysis is chiefly a menace during the very earliest days of its course. But there must be a case to start an epidemic. Consequently any recognized case is obviously the potential center of an epidemic focus and should be promptly isolated. Indeed it might be a more valuable procedure to quarantine the entire household for a short period of time, than to isolate the case and attendant, for 6 to 8 weeks as now advocated by most Boards of Health. It is difficult to hold healthy and busy adults so long in a state of captivity. But it might be easily possible to gain their coöperation for 10 days, so that evasions of the sanitary regulations would not be attempted.

In addition to the protection of the community by adequate quarantine regulations much may be done by individuals to protect themselves. It is only necessary to think how frequently in the course of a day the secretions of nose and mouth, and even the content of the lower bowel are passed either directly or indirectly from one individual to another. How common a sight it is to see someone with a coryza blow his nose into an already saturated handkerchief and immediately thereafter extend a still moist hand to pat a child on the head and face or shake hands with a friend. Several instances arose during the past epidemic which led the writer to enquire what the custom of certain individuals was in the matter of washing the hands after using toilet paper. The surprising answer was that the hands were never washed after that procedure! As a result of these experiences, the following notice is suggested for posting in all water-closets, nurseries, kitchens, and pantries.

NOTICE

INFANTILE PARALYSIS, and other diseases, are carried in the secretions of the nose and mouth, and also in the movements from the bowels.

Think how often your HANDS come in contact with these substances and then how often those same hands touch other people or objects. In this way disease is spread.

Therefore after blowing your NOSE, COUGHING or SNEEZING into your hand, or after using TOILET PAPER, you should wash your hands thoroughly.

There are CHILDREN in this house. Think of them and often wash your hands.

Of similar nature is the danger of transferring nasal and mouth secretions to children by kissing and fondling. It is often difficult to persuade a mother who has been caressing a sick child not to kiss her other children when she leaves the patient. But it would be a wise precaution not to kiss children on the mouth at any time, and during an epidemic of poliomyelitis not at all.

Undoubtedly the most effective means of isolation of patients is hospitalization. Arrangements should be made in advance for the prompt hospitalization of all cases of the disease. Other children in families from which cases are removed should be held in quarantine for 10 days to see if secondary cases develop.

In the hospitals the technique for doctors and nurses and attendants should be that of any properly conducted contagious hospital. Physicians working in the field should wear gowns and masks, wash their hands most carefully or bathe them in bichloride solution (1–5000) or alcohol after completing the examination of the case. All excreta should be disinfected before being sent into the sewage system and all dishes boiled after use.

ORGANIZATION OF FIELD WORK

A good organization for making early diagnosis, giving treatments, and hospitalizing cases in an epidemic center is most important. There should be a sufficient number of doctors with clinical and laboratory experience, working from a central office or laboratory, to go out on call ready to do lumbar punctures and give serum. Each man should carry with him a microscope and counting chamber so that the cell

count of the fluid can be made at the bedside. When enough fluid for the cell count has escaped, the puncture needle with obturator replaced should be left in the back while the count is made so that if serum is indicated it may be immediately injected.

Until late in the epidemic of last summer the use of serum from recovered cases was limited to intraspinal injection. This method was based on the experiments and observations of Flexner and Lewis, who showed that intraspinal injection of serum derived from recovered monkeys or human beings would prevent paralysis in monkeys, after intracerebral injections of virus, and the clinical application made by Netter to human cases. Since then knowledge has advanced and the mode of serum injections improved.

The method consists in obtaining serum from the blood of individuals who have suffered an attack of infantile paralysis. According to Netter subjects most favorable as a source for serum are those whose acute attack lies from 6 months to perhaps a few years in the past. Amoss and Chesney urge the use of serum from cases as soon after the acute attack as possible. The author found that the serum of one case five years after the acute attack was especially effective. The blood should be drawn directly from the vein into a sterile centrifuge tube or flask which can be slanted. By centrifugalization somewhat more serum can be obtained from a given amount of blood than by the still clotting method, and also more rapidly.

The serum is pipetted off and stored in convenient sterile retainers. Serum which contains red blood cells or much dissolved hæmoglobin is undesirable because it often gives rise to severe reactions in the spinal meninges causing headache, intensification of pains, and fever often with chills.

To carry out the intraspinal treatment a lumbar puncture is made preferably with the patient lying on the side with thighs flexed and head bent forward so as to throw apart the spinal processes. After 20 c.c. at least have been removed and it is desirable to withdraw all the fluid that will come, 10 to 15 c.c. of serum are slowly run in by gravity. For in-

travenous or subcutaneous injection a large syringe of 20 c.c. capacity may be used.

When the recent experimental work by Flexner and Amoss is considered, the rationale for combined intraspinal and intravenous or subcutaneous use of immune serum becomes apparent. The fact that injury to the meningo-choroidal defensive mechanism permits the entry not only of infectious agents but also of antibodies from the blood to the subarachnoid spaces makes obvious the indication for this method of treatment. For if the beneficent action of immune poliomyelitis serum be the result of its power to neutralize the virus in the spinal and lymphatic fluids before it becomes attached to the central nervous system, then it is desirable to bring as large a quantity of the serum as feasible into the subarachnoid space. Now it is unwise to inject more than 15 c.c. of serum directly into the spinal canal of a patient suffering with infantile paralysis. This quantity is proper both for adults and for children of two or three years. Below this age the quantity injected should be diminished to 5 or 10 c.c. An intraspinal injection of immune serum therefore has double purpose. It acts directly upon the virus already present in the spinal canal and at the same time by increasing the permeability of the meningo-choroid complex permits the entry by that route of those antibodies circulating in the blood which have been introduced by subcutaneous or intravenous injection.

It is further clear from the experimental work referred to that immune serum is the only fluid which has a restraining effect upon the advancing virus in the cerebrospinal space. Normal horse or monkey serum serves only to destroy the barrier of the meningo-choroid complex but provides no neutralizing substances. It is difficult, therefore, to understand why there should be any curative value in other than specific immune sera, especially earlier in the disease at the time when the serum is most needed.

Serum Group.—During the course of the summer we have been frequently impressed with the large number of cases showing low cell counts in the first twelve or twenty-four hours after the meningeal invasion that did not develop paralysis, and

likewise that many cases with very high counts become paralyzed. It was hoped that definite prognostic assistance might develop from this observation, but a careful subsequent analysis does not firmly establish the assumption. Fatal cases in many instances had cell counts in the neighborhood of 1000 or more. In the latter part of the epidemic when serum was plentiful, and the cases less violent, many patients with low cell counts were treated and recovered without paralysis. The

UNTREATED

Name	Diagnosis puncture: Case no.	Diagnosis puncture: No. cells	Hours after onset of meningeal invasion: 1–6	6–12	12–18	18–24	24–30	30–36	36–42	42–48	Paralysis or not
R. W.	27	230	6								o
W. H.	29	70		11							o
M. A.	17	250		12							o
M. T.	4	40		12							o
V. C.	8	250			18						P
D. M.	15	337				24					o
L. W.	16	370				24					
L. C.	5	40				24					o
R. S.	6	690				24					P Spastic
T. R. D.	7	980				24					o rbc in fluid
H. P.	10	40				24					o
O. R.	11	1180				24					PD
F. McQ.	13	200				24					o
W. Z.	35	90					30				o
G. L.	36	35					32				o
M. N.	28	330						36			o
D. S.	26	504								48	o
W. E.	24	320								?	o
J. M.	20	240								72	P
M. E. A.	21	200								72	P
R. B.	22	220								96	o
D. B.	23	140								96	P
D. S.	18	220								108	PD
E. H.	19	50								48	PW
S. L.	1	40								48	PF
D. S.	9	188								48	o
H. P.	12	260								48	PD
V. L.	14	140								72+	o
J. McM.	33	40								48	
J. McM.	33	190								96	PF
L. G.	34	16								48	o
T. W.	37	70								48	
T. W.	37	80								72	o

o = No paralyses.
P = Paralyses
D = Death.
W = Weakness.
F = Facial.

deduction as to the therapeutic value of the serum treatment in these instances must be very carefully guarded because of the fact that not a few untreated cases with low cell counts also escaped paralysis.

TREATED

Name	Case no.	Cell count	Hours after onset of meningeal invasion								Paralyses or not
			1–6	6–12	12–18	18–24	24–30	30–36	36–42	42–+	
L. J.	6	80	4								o
A. M.	34	80	6							96?	PD
E. L.	28	2430		10							PD
R. L.	30	530		12							o
R. N.	32	2000		8							P
K. McL.	41	320		7							o
J. G.	24	50		7½							PF
E. H.	3	120		10							P
R. J.	4	120		12							PW
W. K.	8	720		8							P
C. L.	11	500		12							o
K. M.	13	130		10							o
H. M.	14	120		9							o
A. C.	19	250		10–11							o
C. S.	39	170		12							o
J. L.	29	490			14						o
B. N.	31	420			13						o
W. E.	25	1200			15						o
M. N.	12	40			18						o
S. M.	17	640			18						P
F. H.	21	400			15						P
G. S.	44	270			17						o
B. G.	26	180				24					o
L. G.	27	430				24					P
T. D.	2	70				24					o
L. J.	5	90				24					o
L. M.	15	140				24					PD
M. S.	16	320				24					o
H. McC.	37	240				24					o
A. S.	38	222				24					PW
C. W.	42	280					30				PW
W. C.	43	215					26				P
M. McA.	35	485					30				PD
O. N.	22	620						35			P
R. M.	23	221						36			P
W. R.	18	325						30			P
H. K.	20	950						36			PD
M. B.	36	240						30			PW
D. D.	1	1420								72	PD
E. K.	7	320								4 das.	o
M. H.	9	425								48	P
M. L.	10	510								48+	PD
A. H.	45	39								72	P
R. E.	46	200								48	o
F. S.	40	130								60	P
A. L.	33	50								48	PW

The tables constructed to show the number of hours elapsing between the onset of meningeal symptoms and the performance of lumbar puncture have been prepared with a view to comparing the results in the untreated and the treated cases. A glance at these tables will show that while it does not follow absolutely that cases with a low cell count do not develop paralysis or that those with a high cell count always do, it is quite obvious that the tendency of the cases showing the higher cell counts in the early hours is toward paralysis. It is also indicated from these charts that after 36 hours the cell count in the spinal fluid is of little or no prognostic value whatever. This observation corresponds to that reported in the monograph. But the cell counts in the first 12 or 24 hours furnish something of prognostic significance as mentioned before in Chapter VIII. Group comparisons are not particularly valuable, especially in view of the difference in the severity of the cases according to the period in the epidemic during which they occurred.

The tables by Amoss and Chesney where the result of combined intraspinal and intravenous or subcutaneous use of serum is reported are somewhat more convincing than those based on intraspinal injection alone. A study of their case reports which follow those of the author are also instructive. Throughout both groups, however, runs the suggestion that cases with low cell counts in the early hours have a better chance of escaping paralysis than those with high counts at the same period.

Zingher[50] reported a large series of gases treated with immune human serum, but gives no clinical records of the patients. His whole presentation of the case for serum therapy rests upon an analysis of percentages. It must be admitted that his figures are more favorable than any others which have been so far published. Thus, of 54 cases treated in the preparalytic stage, 44 recovered without ever developing paralysis; 5 were paralyzed, but recovered ultimately, and 5 were permanently crippled. It would be interesting to know what types of cases were included in this series, and the time at which they were treated.

TABLE I.—REPRODUCED FROM AMOSS AND CHESNEY (JOURN. EXP. MED.). SUMMARY OF CASES THAT RECEIVED SERUM TREATMENT

Case No.	Age	Clinical condition	Spinal fluid		Time between onset of disease and treatment	Serum administration			Temperature before treatment	Time between treatment and normal temperature	Total amount of serum given	Result
			No. of cells	Globulin		Subdural	Subcutaneous	Intravenous				
	Yrs.				Hrs.	c.c.	c.c.	c.c.	°F.	Hrs.	c.c.	
1	33	Ascending paralysis of legs, bladder, and abdominal and thoracic muscles.	280	++	72	10	.....	20	101.2	.....	30	Died 10 hrs. after treatment.
2	10	Ascending paralysis of legs, bladder, abdominal wall, diaphragm, left deltoid, and right facial muscles.	270	++	96	20	60	.....	101.4	24	80	Deltoid and diaphragm functioning 24 hrs. later. Voided 4 days later.
3	3	Right facial and deglutition muscles paralyzed.	208	+	72	15	40	20	104.2	18	75	No further progress of paralysis. Subsequent improvement marked.
4	33	Weakness of left leg and abdominal muscles.	50	+	54	20	.....	50	103.0	60	70	No progress of paralysis. Subsequent improvement.
5	2	Weakness of sternocleidomastoids, both legs, and intercostals.	37	+	96	5	30	.....	98.2	.....	35	No essential change.
6	4	Partial paralysis.	920	++	30	10	25	.....	102.0	60	35	No increase. Complete recovery rapid.
7	2	Weakness of flexors of right thigh.....	99	+	48	5	30	.....	101.4	24	35	No progress of lesion. Subsequent improvement.
8	1 9/12	Weakness of left quadriceps.	.....	.....	48	5	20	.....	102.0	48	25	Slight increase in weakness.
9	3	Weakness of left anterior tibialis.	115	+	72	15	40	.....	100.2	Low fever for 2 wks.	55	Definite increase in extent of paralysis of left leg.
10	1 3/12	Weakness of right deltoid.	30	++	24	5	.....	.....	101.0	24	5	No increase in weakness.

TABLE I (*Continued*)

Case No.	Age	Clinical condition	Spinal fluid		Time between onset of disease and treatment	Serum administration			Temperature before treatment	Time between treatment and normal temperature	Total amount of serum given	Result
			No. of cells	Globulin		Subdural	Subcutaneous	Intravenous				
11	2	Weakness of left peroneal and quadriceps and slight weakness of intercostals.	30	±	12	10	30	.....	101.0	30	40	No increase in paralysis. Rapid disappearance of weakness noted on admission.
12	3½	Slight right toe-drop.	250	++	24	10	40	.....	103.0	24	50	No paralysis.
13	8	No paralysis. Left knee jerk diminished.	850	++	48	5	15	.....	102.5	60	20	Developed partial paralysis in arms, legs, and abdominal muscles.
14	1 7/12	No paralysis.	120	.....	31	5	20	.....	103.0	.....	25	Died in 66 hrs.
15	4	No paralysis.	360	++	36	10	20	.....	103.2	.....	30	Died in 28 hrs.
16	8	No paralysis.	730	++	6	10	20	.....	102.0	96	30	Slight partial paralysis of both arms. Subsequent recovery complete.
17	2	No paralysis.	60	±	36	6	25	.....	102.0	22	31	Subsequent rise to 102°F. Variable temperature for 5 days. No paralysis.
18	5	No paralysis.	379	+	22½	10 (2 doses.)	25	.....	103.4	32	35	No paralysis.
19	4	No paralysis.	150	++	24	10	25	.....	102.4	15	35	No paralysis.
20	1 1/12	No paralysis.	75	++	18	10	25	.....	101.4	22	35	No paralysis.
21	3½	No paralysis.	230	++	66	5	40	.....	102.4	32	45	No paralysis.
22	3½	No paralysis.	88	.....	76	20	30	.....	101.6	36	50	No paralysis.
23	5	No paralysis.	250	.....	30	15	40	.....	101.2	12	55	No paralysis.
24	1½	No paralysis.	40	+	31	25	35	.....	103.0	16	60	No paralysis.
25	5	No paralysis.	260	+	48	22	45	.....	103.2	22	67	No paralysis.
26	23	No paralysis.	40	++	38	20	.....	100	101.0	48	120	No paralysis. Hyperæsthesia disappeared in 48 hrs.

Peabody[51] has recently reported on 51 serum-treated cases in Massachusetts during the fall of 1916. Of these, 51 cases treated in the paralytic stage, 35, or 69 per cent., recovered without ever developing paralysis; 5 cases, or 10 per cent., died within 24 hours; and 11 cases, or 21 per cent., became paralyzed, but 6 of these only slightly. The serum used in Peabody's cases was all from patients whose acute attack was five years or more in the past. It was used only intra-spinally.

TABLE IV.—REPRODUCED FROM AMOSS & CHESNEY, (JOURN. EXP. MED.). RESULTS IN CASES TREATED WITHIN 48 HOURS AFTER ONSET WITH MORE THAN 30 C.C. OF SERUM

Case No.	Time between apparent onset and treatment	Total amount of serum given	Result
	Hrs.	C.c.	
7	48	35	−
25	48	67	+
26	38	120	+
17	36	31	+
24	31	60	+
6	30	35	+
23	30	55	+
19	24	35	+
12	24	50	+
18	22½	35	+
20	18	35	+
11	12	40	+

Table IV shows the result of cases which were treated by Amoss and Chesney early and with large amounts of serum.

The circumstances surrounding the group of fourteen cases, in which no paralysis was detected at the time serum was administered, are more favorable for a conclusion. Two of the patients of this group developed respiratory paralysis and died; and two others developed some degree of weakness or partial paralysis of certain muscle groups. The ten remaining cases (71 per cent.) never showed any detectable weakness.

Serum Treatment.—Obviously no incontrovertible general conclusions can be drawn from a study of the tables and the

foregoing serum treated cases, especially those of intraspinous treatment alone. Each instance must be considered separately.

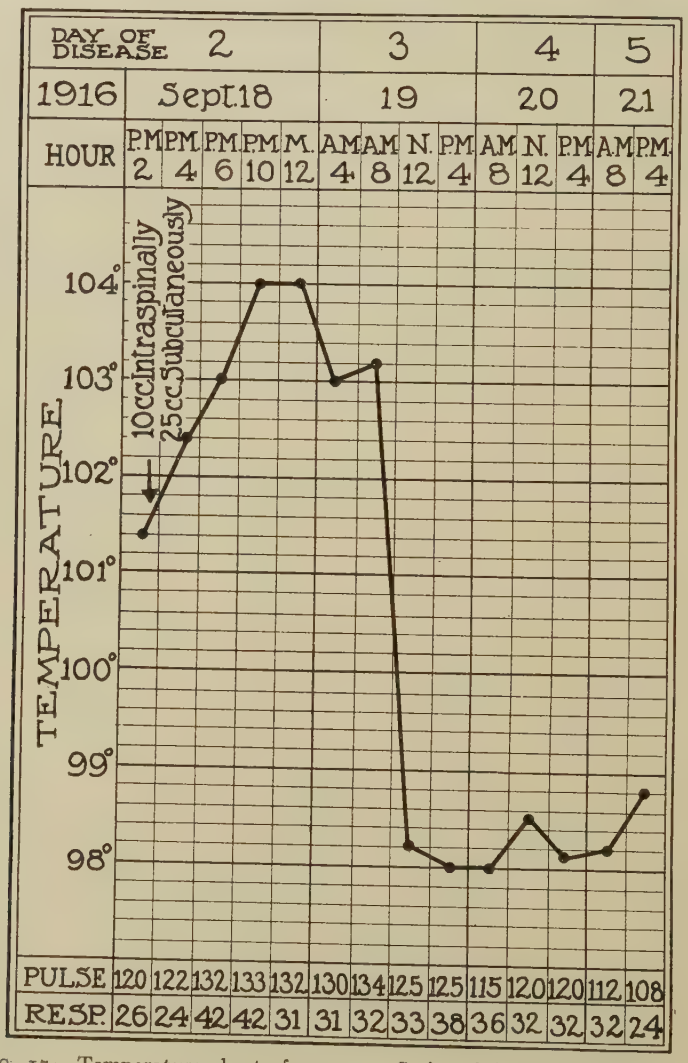

FIG. 17.—Temperature chart of case 20. Series of Amoss and Chesney. (*Journ. Exp. Med.*, 1917, XXV, 599).

But in the study of these cases several interesting points appear. In the first place other excellent examples of the various types described in the section on classification are presented, and

certain unusual events, notably the delayed paralysis (Cases 17 and 22), and the pressure symptoms after treatment (Cases

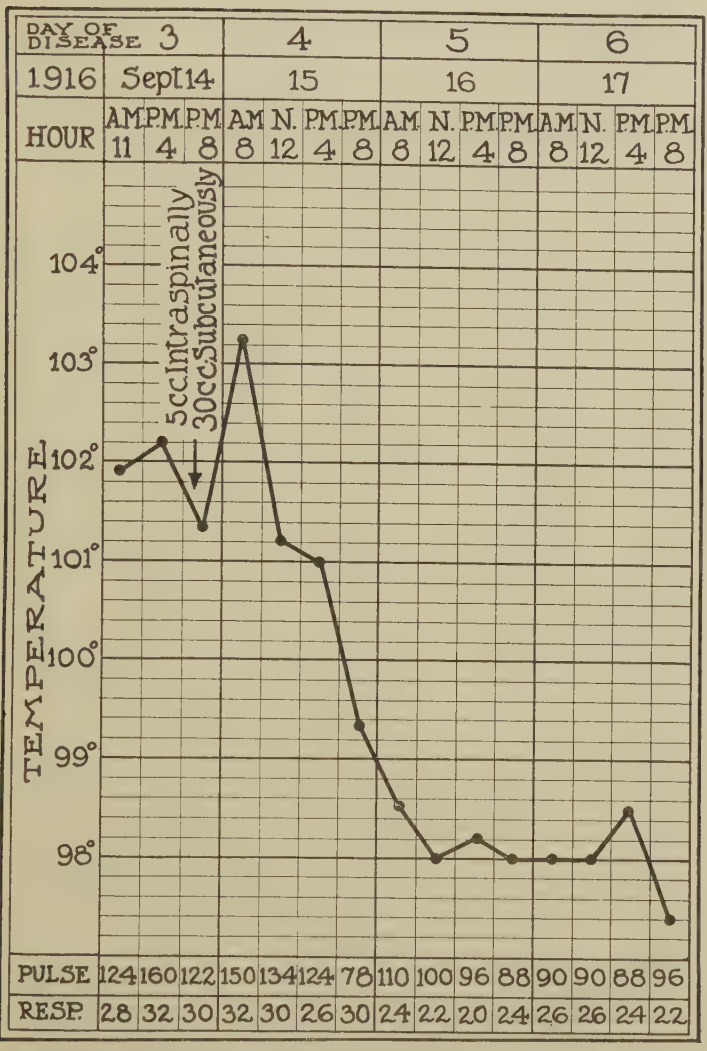

FIG. 18.—Temperature chart of case 7. Series of Amoss and Chesney (*Journ. Exp. Med.*, 1917, xxv, 598).

12, 29, 32, 42, 43, and 25A). Whether the serum played a part in delaying the paralysis in those cases or not is still an open question. Of somewhat similar nature, perhaps, is the obser-

vation that in the treated group there are rather more instances of partial paralysis and transient weakness than in the untreated

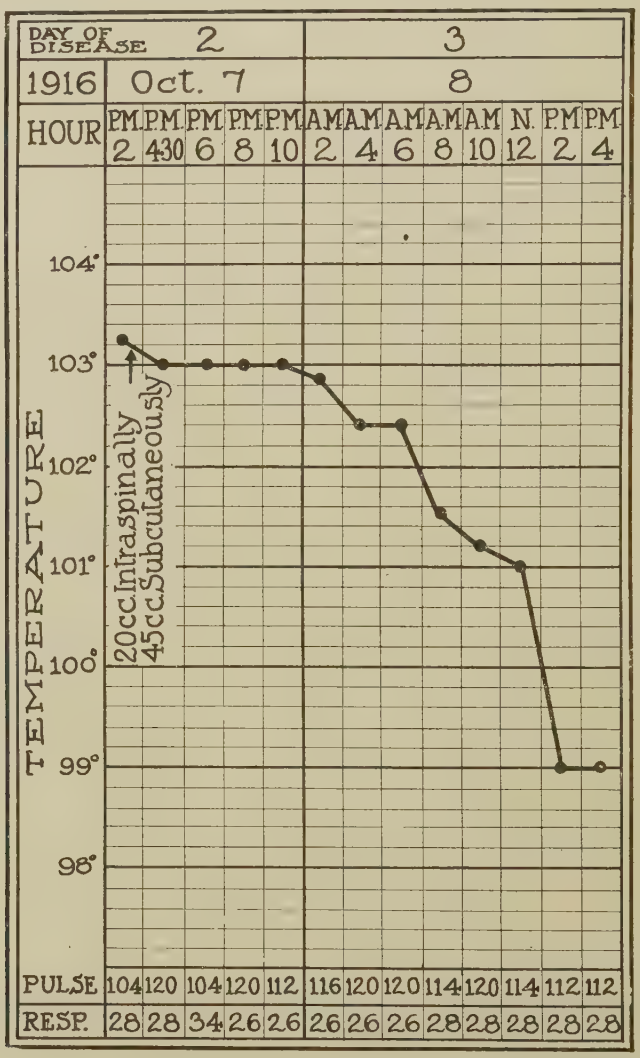

FIG. 19.—Temperature chart of case 25. Series of Amoss and Chesney (*Journ. Exp. Med.*, 1917, xxv, 601).

group. The matter of pressure effect following intraspinal injection is most important and should be specially emphasized. In several cases undesirable symptoms followed treatment

and seemed to be the result of it. Two main types of disturbances appeared; one presenting the aggravation of symptoms of meningitis common to all therapeutic intraspinal injections and to which reference has already been made above (Cases 42 and 43 are examples). The other undesirable reaction is much more alarming and consists of respiratory embarrassment with general collapse. The breathing becomes rapid and shallow, and often irregular (Cases 12, 25A, 29, 32, and 36). In most instances these symptoms rapidly disappear following the release of spinal fluid by lumbar puncture; and it was later learned that they could be avoided by using small quantities of serum (5 to 10 c.c.) and slow injection by gravity method after removal of a larger amount of spinal fluid. It is conceivable that death may be hastened in cases where serum is given in too large doses and two rapidly, after the involvement of the centers of the respiratory muscles has begun. That these occasional instances of the undesirable effects of intraspinal injection occur in the treatment of epidemic meningitis also is well known; but in that disease as in poliomyelitis they are the exception. By withholding immune human serum from the individual suffering with poliomyelitis, the patient may be exposed to a greater and far more frequent danger than that contained in the rather rare chance disturbances due to increased intracranial pressure.

An analysis of the treated cases shows that in four cases in which weakness or paralyses was already present when the first serum treatment was given, there was no restraining effect upon the advancing process (Cases 1, 10, 20 and 21).

Another group which seems not to have been influenced by the serum consists of those cases with low cell counts (50 to 150 per c.mm.) and an isolated facial palsy. This is a very definite type of case, is always mild, and the facial weakness almost always clears up whether treated or not.

The remainder of the series is composed of cases which represent as nearly as possible average examples of this multiform disease. There are numerous instances in which serum was given and paralysis occurred and numerous instances in which paralysis did not occur. The only thing which clearly differentiates many of the cases is the clinical impression at the

time of treatment and this cannot be transmitted adequately in words.

One thing seems to stand out fairly definitely—the need for early introduction of the serum, both intravenously and intraspinally. Working from the hypothesis that the serum operates by neutralizing the virus which is not yet firmly attached to the nervous tissues and so restrains its effects, we attempted to give the serum as soon after penetration of the meninges had occurred as possible. Amoss and Chesney added the intravenous use of serum on the basis already discussed. This appears to increase the therapeutic value of serum, both by providing larger amounts of immune serum and therefore promoting penetration of the serum directly into the nerve tissue as discussed by Mott[52] and by Flexner.[53] In the dromedary type of case the moment of meningeal involvement is often marked with amazing sharpness and, if a child has been under constant and careful observation during the first hump and intermission, it has been possible in several instances to treat within a few hours of the onset of the meningeal stage, or second hump.

In cases of the straggling type, unfortunately, the greatest difficulty is often found in recognizing from clinical signs the moment when the invasion of the meninges occurs. If the serum is regularly withheld until this event takes place there may well be loss of valuable time, for in this disease time is an important factor, after penetration of the meninges has been completed. Consequently every effort should be focused on the detection of the meningeal involvement at the earliest possible moment. In some instances the baffling phenomena of greatly increased cell count without clinical signs of meningitis demonstrates the difficulty of the problem (Cases 11, 14, 21 and 24). Occasionally in the absence of the spine sign (painful anterior flexion of the spine) or negative Kernig a marked onset of drowsiness seems to have been the signal of meningeal invasion. In a few instances loss of one ankle or knee jerk has been the only indication of disturbances of the central nervous system. But these may not mark the beginning. With this difficulty in view the question arises whether the use of serum is not perhaps indicated before signs of central nervous sys-

tem involvement appear. The occurrence of multiple cases in a family is so common that this indication becomes stronger for the treatment of a child developing fever in a family where one member is already stricken. Since the introduction of the intravenous and subcutaneous method, it is no longer necessary to wait for the meningeal stage. Therefore, the earlier the diagnosis can be positively made and serum introduced the better. Now in epidemic areas many cases may be seen so early that a negative spinal fluid is found at the first puncture. This fact brings up the question of the desirability of giving an intraspinal injection of immune serum at this time. It is probably wiser to give a large intravenous or subcutaneous dose at this stage, and puncture again in 10 to 12 hours. If at this second puncture the spinal fluid shows pathological change then the intraspinal serum injection should be given at once, and also another dose by vein or subcutaneously.

When we consider the recorded facts and impressions regarding the use of immune serum, including a recognition of the dangers attendant upon all subarachnoid injections, small though they be, the question arises of the degree and advisability of resorting to the serum at all. This question must ultimately be decided both upon statistical grounds and clinical impressions and observations. As regards the former, attention may be called here to the type of case which presents the picture of a very profound stupor with the isolated facial paralysis. As regards the second consideration, it should be stated that all the physicians who had opportunity to observe came to feel that the serum possessed definite and often striking power to prevent paralysis, especially when the combined method was used. But the impression was also gained that the serum was of benefit, not in all, but especially in those cases in which it was given within about 30 hours from the time of the appearance of signs of meningeal invasion. That the serum is of far less value after the advent of paralysis would appear to be indicated. Yet even that point is one not easily decided and hence, what the limit of its value may be can only be determined from a far larger number of observations.

These observations should also be compared and correlated

with those of Netter whose views on the value of the serum are somewhat more positive than ours. He is definitely of the opinion that cases treated after paralysis has appeared clear up with a speed and completeness that does not occur without the use of serum. Several of his cases belong to the rather common variety with profound stupor already mentioned as having a uniformly good prognosis, so that it is somewhat difficult to credit the serum unequivocally in these particular instances. But it may fairly be questioned whether his protocols really bear out the contention since with him as with us the statistical proof rather fails to bring conviction though the clinical impressions obtained form a strong note in his contribution.

The notion which presents itself from studying this series of cases is that once the meningeal invasion is established, that is 24 to 36 hours after the onset of clear meningeal signs, the chances of arresting the progress of the disease in the central nervous system are already seriously diminished. All this merely means that the serum, if it be employed (but here again the fact must not be forgotten that we are at the beginning stages of the specific treatment of poliomyelitis and may have to revise our judgment later), should be used early, which in turn means prompt diagnosis through careful watching and the lumbar puncture findings. The evolution of the disease is rapid and its course must be considered in terms of hours, not of days. Consequently, any child who develops febrile symptoms without adequate and obvious cause, and then promptly recovers or straggles along half sick, should be watched for the ensuing week with greatest care lest the sudden appearance of a meningeal invasion, insidiously striking while the child is at play or sleeping, take the family and physician unaware and valuable time be lost. But as long as other, surer, and hence better, methods of treatment are not available it is doubtful whether in individual instances we are justified in withholding the serum even at a later stage of the disease than here considered as most promising. The problem is one to be weighed pro and con in the individual case and will doubtless to some extent be decided by circumstances and predilection, and whether serum is readily available or not.

Remembering that it is human serum we are forced to use at present, the supply must always be limited. There must be a choice too as regards source, the medical history of the donor and the length of time since he suffered an attack of poliomyelitis. While it is true that neutralizing bodies may still be detected several years after recovery from the acute disease, yet analogy would suggest the advisability of choosing persons more recently affected. Netter believes the most potent serum is found in individuals whose acute attack lies between three months and four years in the past. It is, of course, always possible that one specimen of serum is less active than another; hence, pooling of the supplies should be practiced when collected, as they should be in advance and in anticipation of the occurrence of cases of epidemic poliomyelitis.

The Wassermann reaction should of course be done on all specimens of serum taken with the view to therapeutic use.

After-care of Acute Stage.—As the child passes from the acute febrile period of the disease it recovers rapidly in general health and well being. If no paralysis has appeared the patient is up and about as well as ever at the end of a day or two if the case be mild, or, at most, a week if severe. In a few cases of very toxic type the febrile period has been much prolonged (Case 29). If paralysis is present care must be taken to prevent positions of arms or legs that may promote contractures. If there is footdrop a right-angle splint should be applied at once, or even a complete plaster bandage, to hold the foot at right angles. When the deltoid is paralyzed the shoulder should be held up by an axillary pad and the arm placed in such a position that no pull comes upon the injured muscle. For further detail in managing the early hours of paralysis and subsequent muscle training the reader is referred to the book by Dr. R. W. Lovett on the After Care of Poliomyelitis.

TREATMENT SERIES

Case 1.—D. D. Female. 22 years. Northport, L. I.

September 14, 1916. Patient's brother Thomas has been in the hospital since last night. Patient awoke this morning with paralysis of both legs. For past three days she has had headache, feverishness, chills,

loss of appetite, and has been alternately restless and drowsy. Did not mention any of these symptoms to anyone because of brother's illness. Temperature 103°. Physical examination shows hyperæsthesia, spine sign and rigidity of the neck. Knee jerks absent. Complete paralysis of all the muscle groups of the legs and thighs, also weakness of the right arm. Lumbar puncture, at 72 hours, shows clear fluid under increased pressure. Cell count 1420. 15 c.c. of serum was given.

September 14, 1916. 9 P.M. Temperature 104°. Increased weakness in the right arm. Had retention of urine; 16 ounces obtained upon catheterization. No other changes.

September 15, 1916. 9 A.M. Right arm completely paralyzed. Beginning respiratory paralysis. Lumbar puncture was performed and 66 c.c. of turbid fluid withdrawn under increased pressure. Cell count 2560. 11 P.M. Respiratory paralysis complete on the right side. Patient cyanotic. Lumbar puncture was again performed and 40 c.c. of fluid withdrawn. 2 c.c. of adrenalin were intraspinally administered.

September 16, 1916. 4 A.M. Patient died of respiratory paralysis.

Discussion.—Paralysis was already present when the patient was given her first dose of serum. The cell count was very high at 72 hours. The case is one of the straggling group, and went on to a fatal issue, the course being uninfluenced in any way.

Case 2.—T. D. Boy. 15 years. Northport, L. I.

September, 12, 1916. Patient awoke with very severe headache. Stopped work at noon, came home and went to bed. Felt feverish. Temperature that evening 104°.

September 13, 1916. Temperature 103°. Patient complains of headache, has stiff neck, exaggerated knee jerks, no abnormal reflexes. There is a definite spine sign. Physical examination, otherwise negative. Lumbar puncture, at 24 hours, shows clear fluid under normal pressure. Cell count 70. 15 c.c. of serum were given.

September 14, 1916. Patient in Huntington Hospital. Temperature 104°. Stiff neck, double Kernig, no change in tendon reflexes. Lumbar puncture: fluid turbid, pressure slightly increased. Cell count 190. 15 c.c. of serum given.

September 15, 1916. Temperature 102°. No other symptoms or signs.

September 17, 1916. Temperature normal. Patient wants to get up.

September 21, 1916. Up and about the ward. No weakness or paralysis.

September 22, 1916. Patient has continued up every day. Apparently well.

Discussion.—This patient apparently had a sudden onset, awaking from sleep with headache. The spinal fluid taken at 24 hours showed 70 cells, a marked contrast to the findings in Case 1, his sister. He received two doses of serum intraspinally, 30 c.c. in all. The first puncture was made 24 hours after the onset.

Case 3.—E. H. Girl. 8 years. Northport, L. I.

September 7, 1916. Child had slight temperature. Vomited once. No other symptoms.

September 12, 1916. When seen to-day the patient's temperature was 101°. Vomited to-day. Knee jerks exaggerated. No rigidity of the neck. No spine sign. No abnormal reflexes. Lumbar puncture: 40 c.c. of clear fluid withdrawn under markedly increased pressure. No cells.

September 13, 1916. Temperature 99°. No new symptoms or signs.

September 14, 1916. Temperature 102°. Slightly stiff neck. Patient complains of headache. No change in reflexes. Lumbar puncture: fluid clear under normal pressure. Cell count 120. 15 c.c. of serum given.

September 15, 1916. 9.30 A.M. Temperature 103°. Child in Hospital. Stiff neck. Knee jerks diminished. Spinal tenderness. Beginning weakness of the left arm, triceps, biceps and deltoid groups. Right arm markedly weak. Flexor and extensor muscles of forearm involved also. Lumbar puncture: turbid fluid under normal pressure. Cell count 160. 15 c.c. of serum given.

September 16, 1916. Flaccid paralysis of the right arm, biceps, triceps and deltoid, flexor and extensor muscles of the forearm. Temperature 102°.

September 17, 1916. Patient stuporous, drowsy. Temperature 100°.

September 20, 1916. Brighter. Temperature normal. Paralysis continues.

September 22, 1916. Motion returning in the left arm. No improvement in the right.

September 29, 1916. Uses left arm quite well. Little return of power in the right. No other muscle groups involved.

Discussion.—Here is a case of the dromedary type in which a puncture was done during the first hump. The fluid is a characteristic one for this stage, large amount, increased pressure and no cells. The globulin determination was not made. After the onset of meningeal involvement the fluid shows moderate increase in cells. The patient was given two intraspinal injections, the first within a few hours of the beginning of the second hump. It is interesting to note what a small increase in cells followed the first serum injection. Paralysis developed.

Case 4.—R. J. Boy. 4 years. Northport, L. I.

September 17, 1916. Patient's sister had poliomyelitis. First symptoms in sister occurred three days ago. Patient sick for the first time this morning. Vomited. Temperature 102°. Knee jerks exaggerated, right more active than the left. No other signs. Lumbar puncture: at about 12 hours, fluid clear, under normal pressure. Cell count 120. 15 c.c. of serum given.

September 18, 1916. Child in hospital. Temperature 103°. Spinal

tenderness. Kernig double. Knee jerks unchanged. Lumbar puncture: turbid fluid under increased pressure. Cells 200. 15 c.c. of serum given.

September 20, 1916. On attempting to sit up, found that lumbar muscles are weak. Some persistent tenderness. Child kept in bed.

September 29, 1916. Tenderness still present. Lumbar muscle weakness. Temperature normal.

Discussion.—This case with 120 cells in the fluid 12 hours after the onset is a mild form. Two doses of serum, 30 c.c. in all, were given intraspinally. Slight weakness of the lumbar muscles developed on the second day.

Case 5.—L. J. Boy. 2½ years. Northport, L. I.

September 8, 1916. Child was feverish and fretful for a day.

September 14, 1916. Child feverish, vomited, does not like to be handled.

September 15, 1916. Temperature 102°. Seems fretful, restless and hyperæsthetic. Had a slight stiff neck. Knee jerks hyperactive, the left more exaggerated than the right. Lumbar puncture, at 24 hours, shows clear fluid under normal pressure. Cell count 90. 15 c.c. of serum given.

September 16, 1916. Child in hospital. Temperature 102.5°. Neck more rigid. Kernig double. No paralysis or weakness made out. Lumbar puncture: fluid clear under increased pressure. Cell count 150. 15 c.c. of serum given.

September 17, 1916. Temperature 101°. Child improving.

September 18, 1916. Temperature 100°. No paralysis or weakness made out.

September 20, 1916. Temperature 99°. Improving.

September 22, 1916. Temperature normal. No paralysis or weakness.

September 25, 1916. Child up and about the ward.

Discussion.—This case is a well-marked dromedary type. Puncture about 24 hours after the second hump showed 90 cells. Two intraspinal injections of serum were given, 30 c.c. in all. Recovery took place without any transient or permanent weakness. In this instance the low initial cell count suggests a favorable prognosis.

Case 6.—L. J. Boy. 5 years. Northport, L. I.

September 13, 1916. Patient's sister, is a positive case, showing the first symptoms 5 days ago. The patient has been previously well. This morning did not want to get up. Temperature 102.5°. Complained of headache and was hyperæsthetic. Reflexes normal. No spine sign. No gastro-enteric symptoms. Lumbar puncture, at about 4 hours, showed clear fluid, under normal pressure. Cell count 80. 15 c.c. of serum given.

September 13, 1916. 9 P.M. Temperature 103°. Stiff neck. Kernig double.

September 14, 1916. 9 A.M. Stiff neck. Knee jerks exaggerated. Kernig double. Temperature 102°. Lumbar puncture: clear fluid under normal pressure. Cell count 150. 15 c.c. of serum given.

September 15, 1916. Signs continue unchanged. Temperature 101°.

September 22, 1916. Temperature normal. No weakness or paralysis. Child up and about.

Discussion.—Another mild case in which the cell count is almost the only indication of meningitis. As in the previous case its lowness has a good prognostic value. The first treatment was given about 4 hours after the onset of symptoms at which time 80 cells were found.

Case 7.—E. K. Boy. 4 years. Northport, L. I.

September 21, 1916. Patient taken sick. His cousin (Case 8) has poliomyelitis whose first symptoms were observed September 6th.

September 25, 1916. Patient has been ill during the past 4 days. Temperature 103°. Kernig, rather marked on both sides. Neck stiff. Knee jerks present, over-active on the right side, and slightly diminished on the left. Spine sign present, rather marked. Lumbar puncture: fluid clear, increased pressure. Cell count 350. 8 c.c. of serum given.

September 26, 1916. Temperature 99°. No change in signs. No new symptoms. Lumbar puncture: fluid clear under moderate pressure. Cells 120. 8 c.c. of serum given.

September 27, 1916. Temperature 101°. Child hyperæsthetic, irritable.

September 29, 1916. Temperature normal. No weakness or paralysis made out.

Discussion.—Here the patient had been ill for 4 days when the puncture was done. There is no means of determining how long the meningeal condition had been present. The marked decrease in cells in the spinal fluid following the first serum injection is interesting. The dose of 8 c.c. was rather smaller than usual. It was repeated once.

Case 8.—W. K. Boy. 18 years. Centerport, L. I.

September 6, 1916. Patient has chills and fever, headache, and has vomited twice.

September 7, 1916. Felt better and went back to work on a boat in the harbor. Headache continued. His condition remained the same during the following day.

September 10, 1916. Headache was very severe and a physician was called. Temperature 100° at 3 P.M. At 8.30 P.M. it was 102°. Neck rigid. Knee jerks greatly exaggerated. Kernig double. Spine tender. There is no paralysis or weakness. No other signs. Lumbar puncture, at 8 hours, shows clear fluid much increased in amount. Pressure increased. 65 c.c. was removed. Cell count 720. Globulin +++; Ross-Jones ++; Pandy +. 15 c.c. of serum given.

September 11, 1916. 8 A.M. Temperature 103.2°. Neck more rigid. Headache increased. Knee jerks exaggerated. Kernig continues.

Spinal tenderness. Lumbar puncture: 60 c.c. of turbid fluid withdrawn. Cells 850. Globulin: Noguchi ++; Ross-Jones ++. 15 c.c. of serum given.

September 12, 1916. 9 A.M. Temperature 101°. Patient slept well, headache much less. Knee jerks obtained. Kernig less marked. No paralysis.

November 27, 1916. Almost complete paralysis of the abdomen and back. Weakness of both legs. Treated at clinic.

Discussion.—This case is a dromedary type with not quite complete remission. The initial spinal fluid count of 720 about 8 hours after the meningeal invasion is dangerously high. Two doses of serum were used, 30 c.c. in all. Paralysis developed. The patient's age and the high cell count are both unfavorable prognostic signs.

Case 9.—M. H. Girl. 4 years. Northport, L. I.

September 10, 1916. No history of exposure or contact was made out. Temperature 102°. Child fretful, drowsy, loss of appetite and diarrhea.

September 11, 1916. Temperature 101°. Vomited.

September 13, 1916. Child up and well apparently.

September 14, 1916. In afternoon child vomited. Temperature 101.5°. Child fretful and irritable. Neck slightly stiff. Knee jerks, left exaggerated, right diminished. Slight meningeal symptoms. Kernig on the left. No paralysis. Lumbar puncture at the end of 48 hours, showed clear fluid under normal pressure. Cell count 425. 15 c.c. of serum were given.

September 17, 1916. Child in hospital. Temperature 102°. Neck very rigid. Tendon reflexes unchanged. Spine sign increased. Lumbar puncture: fluid clear under pressure. Cell count 630. Child apparently much better. No paralysis. Some weakness of right arm.

September 18, 1916. 10 A.M. Temperature 101°. Marked weakness of the anterior tibial and quadriceps group of the left leg. Slight general hyperæsthesia.

September 19, 1916. No new paralysis or weakness. Temperature 100.5°.

September 20, 1916. Temperature 99°. No return of motion in the left leg.

September 22, 1916. Some beginning of motion in the paralyzed extremity.

September 26, 1916. Some improvement in paralyzed leg.

September 29, 1916. Continues to improve.

Discussion.—This case belongs clearly to the dromedary group. The puncture was made 48 hours after the beginning of the second hump, showing a high cell count. Serum was given at this time. A second dose was withheld because the muscular weakness had already appeared. The puncture in this case was unnecessarily delayed.

Case 10.—M. L. Girl. 8 years. Northport, L. I.

September 14, 1916. Child appeared ill. One sister and two brothers positive cases. Cousin, Case 9, a positive case.

September 19, 1916. Patient was ill again 2 days ago, but no physician was called until this evening. When seen the patient's temperature was 103.4°. Neck stiff. Knee jerks diminished. Kernig double. Spine sign present. Weakness of the muscles of the left arm. Lumbar puncture at 48 hours shows clear fluid under increased pressure. Cell count 510. 15 c.c. of serum given.

September 20, 1916. Temperature 104°. Paralysis of the left arm, triceps, biceps and deltoid groups. Lumbar puncture shows turbid fluid under increased pressure. Cell count 600. 15 c.c. of serum given. Patient shows difficulty in swallowing and also acute retention.

September 21, 1916. Respiratory paralysis began last night. When seen at 7 A.M. the patient was cyanotic. Complete respiratory paralysis of the right side. Lumbar puncture: 75 c.c. of fluid withdrawn under increased pressure. Cell count 725. 15 c.c. of serum and 2 c.c. of adrenalin given. Child died of respiratory paralysis at 12.30.

Discussion.—This case is evidently of the dromedary or possibly of the straggling type, but the diagnostic puncture with the first serum injection was made 48 hours or more after the second hump; 570 cells were present then. Furthermore muscular weakness was already present when the first dose of serum was given.

Case 11.—C. L. Boy. 2 years. Northport, L. I.

September 14, 1916. Child became ill. He is a brother of Case 10.

September 19, 1916. Continued ill until to-day. When seen had a temperature of 102°. Neck was slightly stiff and reflexes hyperactive. Lumbar puncture: fluid clear under normal pressure. Cell count 430. 15 c.c. of serum given.

September 20, 1916. Neck still stiff. Slight spine sign. General hyperæsthesia. Lumbar puncture: turbid fluid under increased pressure. Cell count 500. 15 c.c. of serum given.

September 21, 1916. Temperature 101°. No paralysis or weakness.

September 23, 1916. Temperature normal.

September 29, 1916. Temperature normal. Child up and about the ward.

Discussion.—This patient is a brother of Case 10, and represents the straggling type. Puncture, probably within 12 hours of the meningeal invasion, showed fluid with 430 cells. The patient received two doses of 15 c.c., each intraspinally. Both these children presented severe clinical pictures and both had high cell counts. The question arose as to whether they were peculiarly susceptible, especially as they were ill about the middle of September when there was very general evidence that the disease was on the wane.

Case 12.—M. M. Girl. 9 years. Northport, L. I.

September 7, 1916. Slightly feverish.

September 8, 1916. Temperature 102°. Child vomited in the afternoon after taking calomel.

September 9, 1916. Temperature normal.

September 10, 1916. Temperature 101° to 104° during the afternoon. Slight frontal headache. No other symptoms. When seen temperature 103°. Physical examination negative, except for hyperactive knee jerks. No spine sign and no hyperæsthesia. Lumbar puncture, 6 hours after the meningeal invasion: fluid clear, pressure +, cells 40. No serum given because meningeal involvement is slight.

September 11, 1916. Temperature 103°. Neck stiff. Kernig on right side. Knee jerks exaggerated on the left side and normal on the right. Lumbar puncture, at 18 hours. Cell count 140. Globulin: Noguchi ++; Ross-Jones ++; Pandy ++. 15 c.c. of serum given.

September 12, 1916. 10.30 A.M. Temperature 103.5°. Stiffness of the neck much increased. Kernig double. No other abnormal reflexes. Lumbar puncture: increased pressure. Cell count 180. 15 c.c. of serum given.

September 12, 1916. 9.30 P.M. Child delirious. Apparently beginning respiratory paralysis. Acute retention. Temperature 104°.

September 13, 1916. 9.30 A.M. Condition continues much the same except the temperature is 102°. Frequent clonic contractions of all the muscle groups. Neck extremely stiff. Extremely hyperæsthetic. Knee jerks, both markedly hyperactive. Lumbar puncture: fluid turbid, much increased pressure. 60 c.c. of fluid was obtained. 15 c.c. of serum given. The cell count at this time was 300.

September 13, 1916. 8.30 P.M. Temperature 101°. Patient continues to have retention. Less muscular twitching. Still rational. Beginning seropurulent vaginitis. Inability to swallow. Patient beginning to have pressure symptoms. Lumbar puncture was performed at this time and 40 c.c. of fluid removed. No cell count.

September 14, 1916. 9 A.M. Temperature still 101°. Voided spontaneously. Less muscular twitching. Stiffness of the neck less marked. Knee jerks continue hyperactive. Not so hyperæsthetic.

September 15, 1916. Temperature 99.5°. Vaginitis increased in severity in spite of treatment.

September 16, 1916. Temperature normal. No weakness or paralysis. Very marked muscular tenderness in the calves and thighs.

September 18, 1916. Temperature normal. Child much brighter. Vaginitis clearing up. Only complaint is tenderness on manipulation of the legs.

September 22, 1916. Temperature normal. Child continues to be bright and cheerful. No new signs or symptoms.

September 29, 1916. Temperature normal. No weakness or paralysis. Vaginitis cured. Slight muscular tenderness.

Discussion.—This case of the dromedary type is especially interesting in view of the slow development of the meningeal irritation as indicated by the first two punctures. The child became increasingly ill and it was thought she would die, especially when swallowing and respiratory embarrassment set in. Under these conditions there is some doubt as to the advisability of having given the 15 c.c. of serum on September 13. Possibly by its mechanical action it served to increase the pressure on cells already the subjects of pathological effect. At all events great relief of symptoms followed the removal of 40 c.c. of fluid some hours later.

Case 13.—K. M. Girl. 2 years. Northport, L. I.

September 13, 1916. Patient's brother has poliomyelitis, showing his first symptoms September 5, 1913. Patient has temperature 102°. No other symptom or signs.

September 14, 1916. Temperature normal, 1 day interval.

September 15, 1916. Patient feverish and irritable. Temperature 101.8°. Very slight spine sign. Knee jerks on left side hyperactive, on right side diminished. Lumbar puncture, under 12 hours, shows clear fluid under increased pressure. Cell count 130. 15 c.c. of serum given.

September 16, 1916. Temperature 104°. Child refuses to swallow. Apathetic. Spine sign marked. Knee jerks as previously stated. Lumbar puncture: clear fluid under increased pressure. Cell count 150. 15 c.c. of serum given.

September 17, 1916. Temperature 102°. No paralysis. Hyperæsthesia persists.

September 19, 1916. Temperature normal. Child apparently well. Has no tenderness.

September 22, 1916. Temperature normal. No weakness or paralysis.

September 29, 1916. Child up and about.

Discussion.—In this instance the initial puncture and treatment was carried out in less than 12 hours after the onset of the second hump of a clear-cut dromedary type. Note the very slight increase in cells following the first treatment.

Case 14.—H. M. Boy. 7 years. Northport, L. I.

September 5, 1916. Child was feverish and felt sick. Was constipated. Felt better next day. No further symptoms for 7 days until September 12, 1916.

September 12, 1916. At 1 P.M. quiet, did not want to play. Was feverish and constipated at this time. At 8 P.M. temperature was 102°. Child had headache, no other symptoms. When seen complained of headache. Temperature at that time was 101.5°. Had slight stiffness of the neck. Very slight spine sign. Knee jerks were hyperactive. There was a question of a possible double Kernig. No paralysis. No other signs. Lumbar puncture, at 9 hours, showed clear fluid under normal pressure. Cell count 120. 15 c.c. of serum was given.

September 13, 1916. 8.30 P.M. Temperature 102°. Stiff neck. Double Kernig. Spine sign. No paralysis or weakness. Lumbar puncture, fluid turbid under increased pressure. Cell count 150. 15 c.c. of serum given.

September 14, 1916. 11 A.M. Temperature 101°. Marked hyperæsthesia. Signs as previously stated.

September 15, 1916. Temperature and signs continue as above. No paralysis or weakness.

September 18, 1916. Temperature normal. No weakness or paralysis.

September 28, 1916. Child up, and about the room. No weakness or paralysis.

Discussion.—A brother of Case 13; this individual had been carefully watched and his temperature taken twice daily through the 7-day quiescent period. The puncture and first treatment were done 9 hours after the onset of the second hump. These three cases, 12, 13, 14, all lived in the same family and were most carefully observed daily by a competent nurse and the physician in charge.

Case 15.—L. M. Boy. 6 years. Northport, L. I.

September 9, 1916. Patient's two cousins, Case 12 and Case 14, both have poliomyelitis. Patient has temperature 102°. Was very quiet and said he felt sick. Better the following day and showed no symptoms until the 14th, an interval of 5 days.

September 14, 1916. Temperature 100°. Child nauseated, but did not vomit. Severe headache.

September 15, 1916. Temperature 103°. Neck slightly stiff. No change in tendon reflexes. No weakness or paralysis. No hyperæsthesia. Lumbar puncture, 24 hours after the second hump, showed clear fluid under normal pressure. Cell count 140. 15 c.c. of serum given.

September 15, 1916. 10 P.M. (10 hours later). Temperature 103°. Increased stiffness of the neck. Knee jerks hyperactive. Double Kernig. Beginning hyperæsthesia. Lumbar puncture: turbid fluid under slightly increased pressure. Cell count 180. 15 c.c. of serum given.

September 16, 1916. 10 A.M. Temperature 104°. No new symptoms or signs, except a cough and signs of a diffuse bronchitis.

September 16, 1916. 4 P.M. Child refuses to swallow food or nourishment. Acute retention. Respirations increased in rate, but no evidence of respiratory paralysis. Great difficulty in raising mucus which seems to obstruct breathing.

September 16, 1916. 9 P.M. Child still refuses to take nourishment, but when a little fluid is placed in his mouth he does swallow it. Murphy drip started. Compound tincture of benzoin given. Atropine $\frac{1}{2000}$ g. 4 hours. Mucus which is right from the throat is prune-juice color. Chest is full of diffuse râles. Cardiac condition poor. No actual respiratory paralysis made out.

September 16, 1916. 11 P.M. Spasms of bronchi cause great difficulty in breathing. Sibilant and a few sonorous râles occurred in both lungs after the asthmatic attacks. Child was quite cyanosed and the cardiac condition poor.

September 17, 1916. 3 A.M. During one of these asthmatic attacks the child died of cardiac failure. Child died on third day of respiratory failure.

Discussion.—This case is most unusual in its manner of death. Apparently there was some weakness of swallowing, but also disturbance of the bronchial musculature. The possibility of bronchopneumonia cannot be ruled out. He received his first treatment 24 hours after the onset of the meningeal stage.

Case 16.—M. S. Girl. 3 years. Northport, L. I.

September 9, 1916. Child is feverish, fretful and constipated.

September 10, 1916. Temperature is down and remained down until the 13th.

September 13, 1916. Child fretful, feverish and did not want to eat. No gastroenteric symptoms. No sore throat, no vomiting.

September 14, 1916. When seen temperature was 102°. Child very irritable, hyperæsthetic. Knee jerks exaggerated. Beginning stiff neck and very slight spine sign. Lumbar puncture, 24 hours after meningeal invasion, shows fluid clear under increased pressure. Cell count 320. 15 c.c. of serum given.

September 15, 1916. 9.30 A.M. Child in hospital. Temperature 102.5°. No new symptoms or signs. Lumbar puncture; fluid turbid under slightly increased pressure. Cell count 400. 15 c.c. of serum given.

September 16, 1916. Temperature 101°. Hyperæsthesia continues. Knee jerks hyperactive. Spine sign.

September 17, 1916. Temperature normal. Hyperæsthesia continues, also irritability.

September 20, 1916. Temperature normal. No paralysis or weakness.

September 29, 1916. Temperature normal. Child up and about.

Discussion.—This case was punctured about 24 hours after the onset of meningeal symptoms and showed 320 cells. The same treatment was given as in Case 15 and at about the same stage.

Case 17.—M. S. Boy. 2 years. Northport, L. I.

September 11, 1916. Child was feverish, vomited once and was constipated.

September 12, 1916. Fever continues, temperature not taken.

September 13, 1916. Child apparently well, up and about to-day and the following day.

September 15, 1916. Temperature 103°. Child vomited last night. Knee jerks, left hyperactive, right diminished. Neck slightly stiff. Slight spine sign. No paralysis. Slight weakness of the right leg in

sural group and anterior tibial. Lumbar puncture, at 18 hours, showed fluid clear under increased pressure. Cell count 640. 12 c.c. of serum given.

September 16, 1916. Temperature 101.5°. Neck stiff, spine sign. No paralysis or weakness. Knee jerks unchanged. Lumbar puncture shows clear fluid under increased pressure. Cell count 700. 12 c.c. of serum given.

September 18, 1916. Temperature 99.5°. No new symptoms or signs.

September 23, 1916. Child stuporous. No paralysis or weakness.

September 26, 1916. Weakness of the right leg came on this morning.

September 29, 1916. No return of power in the paralyzed leg.

Discussion.—This was a very sick child. The puncture showed 640 cells and was done 18 hours after the onset of the second hump. Two doses of serum were given, 24 c.c. in all. An interesting feature is the delayed appearance of the paralysis, 11 days after the onset of the second hump.

Case 18.—W. R. Boy. 8 years. Northport, L. I.

September 10, 1916. Temperature 104°. Child drowsy and markedly constipated.

September 11, 1916. Temperature 101°. No other symptoms or signs. Remained normal until the 15th.

September 15, 1916. Child complained of being tired. Loss of appetite. Temperature 99.5°. When seen by the local physician there was no rigidity of the neck. No spine sign, and no reflex changes.

September 16, 1916. Temperature was 103°. Very slight rigidity of the neck. Hyperactive reflexes. Slight spine sign. Lumbar puncture, at 30 hours, shows clear fluid under normal pressure. Cell count 325. 15 c.c. of serum given.

September 17, 1916. 9.30 A.M. Temperature 102°. Neck stiff. Knee jerks hyperactive. Paralysis of the biceps, triceps and deltoid groups of the right arm. Lumbar puncture: clear fluid under increased pressure. Cell count 490. 15 c.c. of serum given.

September 17, 1916. 3.00 P.M. Fluid regurgitated through the nose on attempts to swallow. Signs of beginning respiratory paralysis. Temperature 104.5°. Lumbar puncture showed turbid fluid; 40 c.c. were withdrawn under slightly increased pressure. Cell count 520.

September 17, 1916. 5.30 P.M. Complete left respiratory paralysis. Cyanosis. Child died of respiratory paralysis.

Discussion.—This case is an example of the dromedary type with a rather long interval of four days. The meningeal stage began with very inconspicuous signs so that puncture was not requested until nearly 30 hours later. At this time there were 325 cells. The patient received two injections, 30 c.c. in all.

Case 19.—A. C. Boy. 5 years. Inwood, L. I.

August 26, 1916. Brother of patient has been ill with poliomyelitis five days. To-day patient began to vomit—was very drowsy and irritable. Complained of headache and pains in the spine. Temperature 101.4°, pulse 136, respiration 16. Bowels regular, slightly constipated. Physical examination shows the child in bed, of slender build and rather pale. Eyes normal. Throat reddened. Tonsils large. Small cervical glands palpable. Slight spasm of the neck muscles. Lungs normal. Heart, soft systolic murmur, heard at the apex, transmitted to the axilla. Extremities, very slight weakness of the right leg. Knee jerk, faintly present on the left, absent on the right. Slight Kernig present. Other reflexes normal. Puncture within 12 hours shows clear fluid, not under pressure. Cell count 250. Treatment, 15 c.c. serum.

August 26, 1916. Patient presents marked meningismus and pronounced Kernig on both sides. No paralysis present. Temperature 99°. This P.M. there is some improvement. No serum.

August 29, 1916. Child much improved. Temperature 99°. Neck slightly stiff. No paralysis.

August 31, 1916. Child seems ill. Temperature 98°. No paralysis.

September 8, 1916. Child well. Up and around and playing in the yard last week. General condition good. No paralysis or weakness of muscles. Puncture within 12 hours. Cells 250. Headache. Serum one dose. Recovery without paralysis.

Case 20.—H. K. Boy. 19 months. Valley Stream, L. I.

August 26, 1916. Mother noticed that the child felt feverish and later in the day began to vomit.

August 27, 1916. Child very irritable, complains of pain in the back of the neck and head, extremely drowsy. No diarrhea or constipation. Physical examination shows the child lying in bed with slight retraction of the neck. Very irritable and evidently having some pain. Eyes normal. Throat congested. Cervical and inguinal glands are palpable. Lungs and heart negative. Slight weakness of the abdominal muscles. Extremities show no apparent weakness. Knee jerks absent. Other reflexes normal. Slight Kernig on both sides. Marked meningismus. Temperature 102°; pulse 140; respiration 18. Puncture, after 36 hours, showed slightly turbid fluid under slight pressure. Cell count 950. Globulin +. Treatment, 15 c.c. serum.

August 28, 1916. Patient not so well. Diaphragm paralyzed. Respirations rapid and difficult. Child slightly cyanotic. No further paralysis. Treatment, 15 c.c. serum.

August 29, 1916. Child extremely cyanotic. Respirations rapid, shallow and irregular. Pulse 160, very weak. General condition of the child grew worse and death ensued at 3 P.M. Cause of death, respiratory failure. Lumbar puncture was made probably 36 hours after the

onset of meningeal symptoms. Weakness was already present. Cell count 950.

Case 21.—F. H. Boy. 25 months. Valley Stream, L. I.

September 1, 1916. Mother states that present illness dates back two weeks. The child has been more sleepy than usual and has run an irregular temperature which has never been over 100° until to-day, when it jumped to 104°. The child gagged several times this morning but did not really vomit. Bowels constipated. During the last 24 hours the child has been quite peevish and fretful. Physical examination shows a well-developed and well-nourished child, in bed. Mucous membranes normal. Temperature, rectal, 104°, respirations 24, pulse 160. Child is very apathetic and looks extremely toxic. The glands of the neck and groin are enlarged. Child presents a very marked meningismus, and weakness of the rector spinæ. No Kernig. Heart and lungs normal. Extremities, no paralysis or weakness of the muscles could be ascertained. Knee jerks, slightly increased. Other reflexes, normal. Lumbar puncture: 20 c.c. of clear fluid were withdrawn under slight pressure. Cell count 400. Globulin +. 10 c.c. of serum given.

September 2, 1916. Child still very drowsy. Very marked meningismus. Child very toxic and muscles twitch at frequent intervals during sleep. Temperature 103°, pulse 154, respiration 20. 10 c.c. were given 24 hours after the first dose.

September 4, 1916. Temperature 102°, pulse 130, respiration 18. Child looked and acted better. No paralysis or weakness of the muscles noticed. No serum was deemed necessary at this time.

September 8, 1916. General condition much improved. Still slight spasm of the neck muscles. During the past three days there has been apparently some paralysis of the bladder sphincter. To-day the bladder is distended to the umbilicus, and the urine passed is evidently an overflow. Four days ago the child developed paralysis of the quadriceps extensors of the left leg.

Discussion.—About 15 hours after an abrupt rise in temperature in a straggling course the cells were 400. Serum was given then and again after 24 hours. Two days later paralysis developed. There was some weakness of the back muscles, however, at the time of the first puncture.

Case 22.—O. N. Boy. 19 months. Hempstead, L. I.

August 19, 1916. Child became very restless and irritable. The day following was drowsy all day long and his mother stated that he had fever. He had not vomited.

August 21, 1916. Yesterday and this morning the child's arms have twitched convulsively at times. Temperature 100.6°. Physical examination shows a well-nourished white child lying on his back in no apparent pain. His face is flushed and eyes unusually bright. Neck extremely rigid, and child cries out when it is flexed. Throat red. Cervical and

inguinal glands palpable. Chest and abdomen negative. Muscles of the face and eyes are in a semi-spastic condition. Knee jerks are very sluggish. Kernig is mild. When placed on his feet the patient is markedly ataxic. Lumbar puncture shows a clear fluid under slightly increased pressure. Cell count 620. Noguchi +++; Pandy +++; Ross-Jones +++. Patient was very sick and apathetic. At 3.30 the same day a lumbar puncture was performed and 15 c.c. of clear fluid withdrawn. 15 c.c. of serum was injected intraspinally. Child appears bright to-day. No definite paralysis, but knee jerks are absent. Wanted the child removed to the hospital but had no place to take it at the time.

August 22, 1916. 9.30 A.M. Lumbar puncture: 15 c.c. of clear fluid withdrawn. 15 c.c. of immune serum were given intraspinally. Child appears brighter to-day. No definite paralysis but knee jerks are absent.

August 27, 1916. Not drowsy now. Paralysis of left lower extremity (partial paralysis).

August 31, 1916. 4 P.M. Temperature 98°. Paralysis of the left extensor groups continued. Weakness of the same group in the right leg. Ankle and knee jerks are absent. Slight spinal tenderness.

Discussion.—Here the diagnostic puncture showing 620 cells was done about 30 hours after the onset of symptoms. Serum was not given until 35 hours after. The case is a very severe one. Paralysis did not appear until the seventh day. Two doses of serum were given, 30 c.c. in all.

Case 23.—R. M. Boy. 9 years. Freeport, L. I.

August 16, 1916. Child had headache and nausea but did not vomit. No diarrhœa. Rather drowsy. Not irritable at any time. Complained of slight pain in the back of the neck on flexion.

September 17, 1916. Patient somewhat apathetic with flushed face. Eyes unusually bright. At times spasmodic twitching of the facial muscles. Throat extremely red. Neck very rigid, pain being caused on attempt at flexion. Spine rather rigid. All reflexes present. Lumbar puncture. Cell count 220. 15 c.c. of serum were given. Pandy, Noguchi and Ross-Jones, all +.

August 18, 1916. At 12 M. 15 c.c. of immune serum were given. Cell count 50.

August 18, 1916. At 8 P.M. 15 c.c. of immune serum were given. Cell count 440.

August 20, 1916. Slight weakness of the deltoid appeared yesterday, but is absent to-day.

November 25, 1916. The paralysis of the eye and deltoid were temporary. No permanent paralysis.

Discussion.—At 36 hours 220 cells were found. There was temporary weakness of the right deltoid on the 4th day. The patient received three doses, 45 c.c. in all, of serum intraspinally.

Case 24.—J. G. Girl. 14 months. Oyster Bay, L. I.

August 22, 1916. About 6 o'clock the patient's parents noticed that she did not appear well. She was unusually drowsy and fretful and seemed to feel hotter than usual. No vomiting or diarrhœa. Does not seem to be in pain. Physical examination shows the child apathetic, in bed, but in no apparent pain. Eyes negative. Upper teeth widely spaced. When crying the right side of the face is drawn over to the right slightly. Throat is very red and contains an accumulation of glairy mucus. The cervical, axillary and inguinal glands are enlarged. Neck is rather rigid. Reflexes are all present. Lumbar puncture: 15 c.c. of fluid were withdrawn under increased pressure. Cell count 50. Noguchi +; Pandy +; Ross-Jones +−. 15 c.c. of serum were injected. Slight facial paralysis. The child was removed to the Locust Valley Hospital.

August 28, 1916. Slight facial paralysis still persists. Child seems very well.

Discussion.—The patient was seen when a facial paralysis was present. Puncture done at this time, which was about 7½ hours after the onset of symptoms, according to the mother, showed a fluid containing 50 cells. One dose of serum was given.

It is interesting to note that this combination of a low cell count with an isolated facial paralysis was a very frequent finding.

Case 25.—W. E. Boy. 13 years. Hempstead, L. I.

August 23, 1916. Boy does not feel well.

August 25, 1916. Mother noticed that the boy had fever and was rather drowsy. He complained of headache and some pain in the chest when the head was bent forward. Not irritable. No vomiting or diarrhœa. Physical examination shows temperature 102.3°. Patient is a well-developed boy of 13 years. Cheeks are flushed, skin hot and dry. Eyes negative. Tongue coated. Throat slightly redder than normal. Neck quite rigid and patient complains of pain over the sternum when the head is bent forward. Chest and abdomen negative. Knee jerks very sluggish. Lumbar puncture: 20 c.c. of cloudy fluid was withdrawn under increased pressure. Cell count 1200. Noguchi ++++; Pandy ++++; Ross-Jones ++++. 9.45 P.M. Lumbar puncture: 15 c.c. of cloudy fluid withdrawn. 15 c.c. of immune serum given intraspinally. Cell count 1600. Patient complains of headache to-day. Neck extremely rigid. No paralysis. Marked resistance to extension of the legs with thighs flexed.

Note.—Patient's brother has poliomyelitis, recognized 3 days ago.

September 1, 1916. Temperature normal for the past three days. Up and about. No weakness or paralysis. Complains of muscle pains, especially at night. Had serum 1 week ago.

Discussion.—This patient presented the very high cell count of 1200 about 12 hours after the onset of drowsiness and pain on anterior flexion of

the head. Besides this he was very toxic and much prostrated. There was marked meningeal irritation following treatment. He received two doses of serum, 30 in all. The first injection was given at about 15 hours.

Case 25*a*.—C. L. P. Boy. 10 months. Sayville, L. I.

August 24, 1916. Child had green stools and a temperature of 102°. Oil was given.

August 25, 1916. Child appeared much better. Temperature 98.6°. No vomiting.

August 26, 1916. Child rather drowsy and irritable.

August 27, 1916. Temperature 103.2°. A well-developed boy of 10 months. Fontanelle not bulging. Eyes negative. Throat rather red. No rigidity of the neck. Cervical and inguinal glands enlarged. Chest and abdomen negative. Knee jerks exaggerated, especially on the right side. Apparently some weakness of the right quadriceps and psoas. Lumbar puncture: clear fluid under increased pressure. Cell count 50, at 72 hours.

August 29, 1916. 10 c.c. of serum given at 11 A.M., at 72 hours. Temperature at this time 103°, and respirations about 80 per minute. Temperature rose in a few hours to 104° and respirations became more shallow and at 7 A.M. it was thought that death would supervene. In a short time it was thought that the child could not swallow well. Since this time there has been a progressive improvement.

August 31, 1916. Child is reported as seemingly perfectly well.

September 1, 1916. Complete recovery. Paralysis of the pharynx was only transitory.

Discussion.—This case showed 50 cells at 72 hours. 10 c.c. of serum was given at 78 hours. There was transient weakness of swallowing. The child was much worse following serum. Patient was breathing 80 per minute at the time the serum was given. The serum should have been withheld, but the father, a physician, insisted that it be given.

Case 26.—B. G. Girl. 13 years. Great Neck, L. I.

August 25, 1916. Patient had a temperature of 101.5° and felt poorly.

August 26, 1916. Temperature was normal and the patient was up and around all day.

August 27, 1916. Temperature continued normal and she went in bathing, but in the evening complained of headache and at midnight had marked spinal tenderness.

August 28, 1916. Patient vomited and had a temperature of 101.5°. She was seen at 11 A.M. She is a large girl for her age and is menstruating. She is a healthy child and does not appear particularly sick. She has a headache when she moves her head. Slight spine sign. Reflexes: biceps ++. Knee jerks and ankle jerks absent. No weakness. At 4 P.M. Temperature 101°, headache better. Spine sign the same. Spinal

puncture at 24 hours shows fluid clear, under increased pressure. Cell count 180. 12 c.c. of serum were given.

August 29, 1916. Patient has had a good night and feels better. Temperature normal.

Discussion.—This patient was not very toxic, but 24 hours from the onset of the second hump had 180 cells. She received one dose of serum which did not set up any meningeal irritation. She then followed an uneventful and short course to recovery.

Case 27.—L. G. Boy. 7 years. North Hempstead, L. I.

August 21, 1916. Child had a poor night. No vomiting but slight temperature. Was given catharsis which was successful. Was not drowsy.

August 22, 1916. Seen at 7.45 A.M. this morning. Child flushed, slightly sore throat, acute febrile picture. Definite spine sign. Knee jerks ++. Spinal puncture: made under 24 hours shows fluid clear, pressure low. Cell count 430. Globulin +. 15 c.c. of serum given. Patient grew worse during the morning and embarrassment of the respiration began on the right side, and weakness of the right arm with distinct weakness of the neck muscles. At 5 P.M. 15 c.c. of fluid was withdrawn. Pressure at this time was 6 mm. of mercury. 15 c.c. of serum was run in. Cell count was 770. Vomiting followed. There was no sign of respiratory paralysis at this time. Knee jerks ++. Temperature 103.

August 23, 1916. 7.00 A.M. Temperature 101.2. Paralysis of the right arm has increased. Patient has had a restless night, but is resting easily this morning. Spinal pressure very low, only about 5 c.c. being removed. Cell count 120. 15 c.c. of serum were injected. No vomiting followed.

August 23, 1916. 9.45 P.M. Left arm has become involved, so that patient is unable to lift it from the side to any extent. Neck does not seem so rigid. Temperature about the same as this morning. 15 c.c. of immune serum given with 1½ c.c. of adrenalin chloride. Cell count 180.

August 24, 1916. At 10 A.M. Patient distinctly better. Temperature lower, left arm not so helpless, being able to raise it to the right-angle position. His general appearance is better. Had a restless night.

August 29, 1916. The child is doing very well, but has paralysis of both arms. The paralysis of the left arm is only of the deltoid muscle.

Discussion.—Puncture and first treatment, just under 24 hours. Cell count 430 cells. There was slight transient embarrassment of the respiration during the next 6 hours; then involvement of the arms. The patient received four doses of serum, 60 c.c. in all. This was a very sick case. Possibly a fatal issue was prevented.

Case 28.—E. E. L. Girl. 3 years 10 months. Oyster Bay, L. I.

August 21, 1916. Suddenly at 10 o'clock this morning the child was

seized with pain in the back of the neck. She continued to play until 12 o'clock when she gave up and began to be feverish. Became rapidly worse. At 3 P.M. her temperature was 102.6. At 7 45 P.M. it was 102.4. Physical examination shows a well-nourished child. She presents an acute febrile picture, with definite fine ataxic tremor on motion. Knee jerks are absent. Patient is apprehensive and nervous. There is no weakness. Spinal puncture: fluid hazy. Pressure normal. Cell count 2430. 15 c.c. of serum given.

August 22, 1916. At 7 A.M. The child is slightly improved. Has had a fair night with 6 hours sleep. Bowels have not moved and no food has been taken since the last visit. Physical examination shows stiffness and tenderness of the neck and spine, and a positive Kernig in each leg. There are no paralyses or weaknesses made out. Temperature is 102.2. Lumbar puncture: 20 c.c. of cloudy fluid was withdrawn under normal pressure. Examination of this fluid at the bedside shows it to contain 2220 cells and no red cells. The Globulin reaction is very marked. Fehling's reaction positive.

August 22, 1916. 9.30 P.M. Patient has rather suddenly assumed an opisthotonos position. Temperature 103. Face is quite flushed, breathing somewhat rapid. 15 c.c. of serum together with 1½ c.c. of adrenalin chloride were given intraspinally. Cell count was not made.

August 24, 1916. Temperature is about 1° lower than on the previous day. Opisthotonos still continues and paralysis of the right arm with weakness of the left. Cyanosis of the lips and face and evidence that the accessory respiratory muscles are involved. Spinal puncture: 15 c.c. of serum together with 1½ c.c. of adrenalin were given. Cell count 250.

August 25, 1916. 10 A.M. Patients condition is very poor. Temperature is high, pulse rapid, appearance cyanotic. 2 c.c. of adrenalin chloride were administered intraspinally. Child died at 11.30.

Discussion.—Overwhelming infection. Puncture and first treatment 10 hours after the onset of meningeal symptoms showed 2430 cells.

It is interesting to note that after 2 months the mother remembered what she had failed to mention at the time of the child's sickness, that the child had been feeling poorly on the previous day. Possibly this case, then, which has been reported in the group of sudden meningeal onsets belongs to the group of straggling courses with a very short duration.

Case 29.—J. L. Girl. 6 years. Garden City, L. I.

August 23, 1916. This morning before breakfast the patient seemed not to be well. During the morning she was drowsy and vomited but ate her lunch. In the afternoon her temperature was 100. At 7 P.M. it was 102.5. The patient is a large girl for her age. There is a light tremor of the face and hands on motion. Spinal sign is fairly marked. Patient is flushed and acutely sick. Knee jerks and ankle jerks ++.

No muscular weakness. Spinal puncture: fluid clear, pressure slightly increased. Cell count 490. Globulin ++++. Patient was given 15 c.c. of serum at 9 P.M. after the removal of 20 c.c. of fluid; she was relieved by the injection. This was followed by cramps in both legs.

August 24, 1916. 9. A.M. Patient had a good night, some twitching, no vomiting. Temperature 100.6. Slight headache. Knee jerks, both positive. Cells 2540. 15 c.c. of serum given after the removal of 20 c.c. of fluid. Again cramps in the legs.

August 24, 1916. 7 P.M. Following the last injection the patient complained of pain in the bladder. She is very alert, trembling and nervous. Respiration rapid, pulse rapid. Knee jerks +; the Achilles jerk in the left ankle is negative. Right Achilles jerk is present. Spinal puncture: fluid turbid, pressure increased. 15 c.c. of fluid removed and 10 c.c. of serum given. Cell count 2962. Patient was drowsy and nearly went to sleep while the serum was being given.

August 25, 1916. Patient in stuporous condition most of the day. Is flighty when aroused. Temperature 103. Possibly slight weakness of the deltoid, shown as early fatigue. Knee jerk ++. Ankle jerks both present.

August 26, 1916. Patient had good night. Temperature 100.4. This morning after exertion caused by changing the bed, the patient went into collapse. Recovery was prompt. Pulse very weak, rapid. When seen at 9 o'clock patient was prostrated, pulse fair, respiration very shallow. MacEwen ++. Knee jerks ++. Ankle jerks, right plus, left negative. Heart action and sounds good. Puncture was done to relieve pressure. Fluid clear, pressure ++. Cell count 25. Globulin +. About 20 c.c. of fluid removed. MacEwen's sign disappeared. During the day the patient was in a stupor. She is probably a case of the true encephalitic type. Reflexes are all double plus. There is a tendency to spasticity. Respiration became deeper after the removal of the fluid. When fed swallows only on order. Makes violent grimaces on opening the mouth, some twitching and athetoid motions. Respiration irregular.

August 27, 1916. Patient awoke early in the morning and spoke clearly to the mother. Temperature 100, pulse 120, rather poor force but not bad. General condition shows some improvement. Still somnolent and psychically detached. Eats better but still with violent mouth opening. Temperature began to rise this afternoon.

August 28, 1916. Patient continues in semi-stupor. Puffiness of the eyelids this morning. Takes nourishment automatically. Temperature 101, pulse 112, good quality. Twitching less. In the afternoon the temperature began to rise again. Patient still refuses to answer and looks blankly at her mother without recognition.

August 29, 1916. Patient much clearer mentally. Temperature 99. Marked exaggeration of all reflexes, slight unsteadiness and general weak-

ness of the arms on raising, but probably not due to cord lesion. It seems more like general disability.

August 30, 1916. Last night the temperature rose as high as 102.6. Patient was somewhat distended and was given castor oil. Good results in the morning. Temperature now 101.4. Patient is quiet, clear mentally and relaxed. Physical examination shows the eyes apparently normal, but there is slight puffiness of the lower lids. Throat a little red. Uvula appears to be absent. The lymph nodes, both the anterior and the posterior cervical are palpable. Bladder is markedly enlarged, especially on the right side. The axillary nodes are also markedly enlarged, as well as the epitroclear and inguinal glands. Heart and lungs are apparently normal. The liver is felt in the anterior axillary line about a finger's breadth below the costal margin. The spleen is not felt. Reflexes are all present except the ankle jerks, which are not obtained this morning. There is no muscular weakness made out.

August 31, 1916. Patient's temperature has been rising slowly and steadily. This morning there is a positive MacEwen sign. Another puncture was suggested on the possibility of increased intracranial pressure. The family wished to postpone this. At 6 P.M. the temperature was 104.6. Patient seemed in good condition and bright, and not as sick as temperature would indicate. Spinal puncture: fluid clear, pressure low. 15 c.c. of fluid withdrawn. Cell count 105. All but a very few of the cells are small lymphocytes.

September 1, 1916. Patient is apparently in the same condition as yesterday. Temperature has dropped to 102.6. She is complaining now of a great deal of pain and tenderness in her joints, shoulders and knees, especially. Midday temperature again arose to 103. Aspirin was ordered, 5 grains every 3 hours. The patient has had pains all day and last night in her joints and muscles. Marked palpitation was noted. Patient is tender and when touched has many pains. Temperature 104.5. She eats well and seems in good condition generally. She is not as sick as her temperature would indicate. Pulse full and of good quality. At noon she was given 5 grains of aspirin; 2 hours subsequently she perspired freely and went to sleep. At 3 P.M. temperature has fallen to 101.3.

September 3, 1916. Temperature continues high, between 102 and 104. General condition remains unchanged.

September 7, 1916. Patient's temperature has been normal for 3 days. She seems very much better in all respects though considerably prostrated. No weaknesses are made out. Reflexes are all present, except the left ankle jerk. The neck is no longer stiff.

Discussion.—This is a most unusual case in the length of its course. The marked meningeal irritation following treatment and the profound psychic disturbance are interesting features. There is no doubt that the respiratory embarrassment was relieved by the withdrawal of fluid.

The first treatment was given about 14 hours after the onset of symptoms. The cells at this time were 490.

Case 30.—R. L. Boy. 7 years. Roslyn, L. I.

July 27, 1916. Patient seemed rather quiet during the morning and instead of his usual activities was lying about on chairs and sofas. At this time he complained of headache and feeling lazy. Eyes were definitely puffy. There were no weaknesses made out. Reflexes were present and slightly exaggerated. Spine sign was positive but not marked. Heart and lungs were normal. Lumbar puncture, at 6 hours, showed hazy fluid, under increased pressure. Cell count 530. At 12 midnight, about 12 hours after the onset, patient was given 20 c.c. of serum from a recovered case. Next morning the spine sign was very much more marked. Patient tended to assume the opisthotonos position. Marked and increased rigidity of the spine. Patient very tremulous and somewhat ataxic in the arms.

July 28, 1916. Patient given 20 c.c. of serum intraspinally. Fluid withdrawn is cloudy. Cell count about 3000. Condition the same with spinal tenderness and rigidity of the neck. Marked exaggeration of all the reflexes. During the night there was severe twitching of the arms, legs and face. Patient vomited once.

July 29, 1916. 9 A.M. Patient punctured again. 20 c.c. of fluid withdrawn. 15 c.c. injected. The cell count has dropped to 77. During the injection the patient had a very considerable nose-bleed, and complained of abdominal pain. The same signs of meningeal irritation are presented. There is slight weakness of the left deltoid. At 10 P.M. the patient was given the fourth injection of 10 c.c. of serum. Cell count lost. Spastic condition continues.

July 30, 1916. 9 A.M. Patient is given the fifth injection of 7 c.c. of serum. The fluid is perfectly clear. Cell count 50. Patient continues spastic with a continued spine tenderness, maintaining a marked contraction of the neck, and flexion of the face and knees. Reflexes all exaggerated. No weakness made out. The weakness of the deltoid has apparently disappeared. During the night there were severe contractions of the muscles. Patient complained again of abdominal pain during the injection of the serum. Temperature came to normal on this date, and remained so subsequently. The tender spine and spastic condition persisted until the middle of August, and gradually disappeared.

Discussion.—The patient was very toxic from the start and showed a high cell count within 12 hours of the onset of the headache and drowsiness. He developed intense meningeal irritation following the treatment, shown both by the high cell count and extreme spasticity and opisthotonos. He received five intraspinal injections, amounting to 77 c.c. This case was one of the earliest ones to be treated and received the

largest doses—20 c.c., and also the greatest number. Later on smaller and fewer doses were given.

Case 31.—B. N. Girl. 8 years. Westbury, L. I.

July 29, 1916. Patient was ill with tonsillitis which lasted three days. There was then a 4-day interval with normal temperature and the patient seemed better.

August 5, 1916. This morning the patient complained of headache, and was found to have a stiff neck. Lumbar puncture, within 6 hours, was done by Dr. DuBois from the New York City Department of Health. A small amount of fluid was obtained, and the cell count by the dry method indicated an increase above normal. Albumin was also positive. At 7.40 P.M. About 12 hours later, the patient was punctured a second time. 25 c.c. of fluid was removed under moderate pressure. Cell count 420. The patient was given 20 c.c. of serum. Patient is large, rather fat type of girl. Knee jerks are very hard to get. The biceps jerk is not obtained. She has a painful spine.

August 6, 1916. In the afternoon the patient was punctured again. Fluid was clear, pressure, normal. Cell count 380. 7 c.c. of serum was administered. Knee jerks were present.

August 7, 1916. Neck still stiff. Kernig sign present. No weakness. Biceps jerks were not obtainable. Knee jerks were present. Temperature 100.3. Lumbar puncture: under ether. Fluid clear, slightly tinged with red cells. Pressure normal. Cell count 290. 12 c.c. of serum given.

August 8, 1916. Patient seems much better to-day. Meningismus marked. Knee jerks are present, but hard to get. This is the end of the fourth day or the beginning of the fifth.

August 12, 1916. Meningismus practically gone. Right knee jerk present, but much less than the left.

Discussion.—This case is a well-marked dromedary type in which the first hump is definitely associated with a tonsillitis. A number of such cases were seen. There was very little response to treatment so far as the meningeal irritation was concerned. The child was very sick during the whole course of the treatment. She recovered without any weakness having appeared. Her first puncture was made within 6 hours of the onset of meningeal symptoms and the first injection of serum at about 12 hours.

Case 32.—R. N. Boy. 4 years. Westbury, L. I.

August 6, 1916. Brother of Case 31. Similar in looks. Sudden onset, with restlessness during the night. At 7 A.M. vomited and had stiffness of the neck. Physical examination at 10.30 A.M. showed the spinal fluid clear under low pressure. Cell count 2000. 7 c.c. of serum were given. The serum entered with difficulty and cramps of the legs followed the injection. At midnight the child was chloroformed and 25 c.c. of

fluid removed under slightly increased pressure. Fluid was cloudy. Cell count 4500 (mononuclears). 15 c.c. of serum was given.

August 7, 1916. Patient again etherized and puncture performed. Fluid very turbid. Cell count 1800. Pressure normal. 20 c.c. of serum was given. During the night breathing became very bad, 50 per minute and very shallow. The condition seemed more like respiratory center involvement, for the diaphragm and thoracic muscles were working.

August 8, 1916. Patient shows a slight tendency to favor the right thigh and leg. No definite paralysis, but slight weakness of the extensor groups, above and below. Patient was given 12 c.c. of serum. Fluid was clear. Pressure normal. Cell count 177.

August 9, 1916. Patient had rapid breathing during the night. This morning markedly prostrated. Declines to move the right leg.

August 11, 1916. There has been slow but progressing weakness of the respiratory center, but no paralysis. Deltoids are apparently flaccid. There is also great weakness of the thighs.

August 12, 1916. Breathing better this morning. Both groups acting more extensively. Spontaneous flexion of the left foot in sleeping.

August 16, 1916. Patient much better. Generally stronger. Both respiratory groups acting more forcible. Continues to demand constant changing of position. No change in flaccid muscle. Neck is stronger.

August 18, 1916. Left forearm all right. Deltoid, biceps and triceps flaccid. Right deltoid, biceps and triceps weak. Right forearm weaker than the left. Lower right quadriceps very weak or absent. Anterior tibial group weak. Left tibial group weak, but much more active than the right. Breathing almost back to normal. Spinal tenderness still very marked.

September 6, 1916. Since last note the patient has continued to improve in general condition. Spinal and muscular tenderness which has persisted until a day or two ago at almost its original intensity has only just begun to diminish. Diminution of this tenderness has made it possible to determine that the paralyses are improving. There is practically complete use of all the muscles below the knee on both sides. The quadriceps on both sides, however, are apparently gone. The flexion of the thigh is possible through the action of the psoas. The upper extremities: on the left side there is almost complete use of the forearm and hand muscles, also of the biceps. The triceps and deltoid, however, are still practically useless. There seems to be a slight return of power to the deltoid. The right arm: there is marked weakness of the flexors of the fingers. There is much greater weakness of the biceps than on the left side. Like the left side there is almost complete uselessness of the triceps and deltoid, but here is also apparently a slight return of power in the deltoid.

Discussion.—This case was by far the sickest patient of any that lived. He was profoundly toxic and had intense meningeal involvement. The

exhaustion of the respiratory mechanism was very unusual for it was apparently a central affair. Whether the fact that the two worst slumps in his breathing followed intraspinal injections is of significance or not is open to discussion. The first puncture and treatment came within 8 hours of the onset of meningeal symptoms, disclosing the very high count of 2000.

Case 33.—A. L. Male. 32 years. Oyster Bay, L. I.

August 21, 1916. Patient felt poorly.

August 22, 1916. He felt all right.

August 23, 1916. He felt feverish and somewhat "dopey."

August 24, 1916. Complains of headache, feverishness, and slight stiffness of the neck. Temperature 102°. Patient is a large, bony individual. Pharynx is congested and he has a slight cough. Heart and lungs are negative and there is no explanation of the temperature except the onset of an attack of poliomyelitis. Knee jerks are present. Neck is slightly rigid. Spinal puncture: fluid clear and shows no cells. Pressure, 3 mm. of mercury. Globulin +. No history of vomiting or constipation.

August 25, 1916. Temperature 101°. Patient still has cough, complains of headache and feels weak. Spinal puncture: fluid is clear with no cells and no increase of pressure. Neck is distinctly stiff but not markedly so.

August 26, 1916. Temperature 100.8°. Neck more rigid. Did not sleep well last night, feels restless. There is considerable tremor of both hands, especially of the right side. No kernig or clonus. Knee jerks still present. Spinal fluid, at about 48 hours, is clear, but shows about 50 cells. Globulin +. 15 c.c. of serum were given with 1½ c.c. of adrenalin chloride. The patient was then taken to the Locust Valley Hospital.

August 27, 1916. Running a slight temperature. 15 c.c. of serum were administered.

August 29, 1915. Temperature normal. Patient feels well and would like to get up. There is evidently very slight weakness of the muscles of the right leg.

Discussion.—This patient is the father of Case 28. The case is especially interesting because of the series of punctures, the slight meningeal involvement, 50 cells, and the partial and transient weakness. It was not until about 48 hours that cells first appeared in the spinal fluid and serum was injected.

Case 34.—A. M. Boy. 8½ years. Great Neck, L. I.

August 28, 1916. Patient complains of headache. Lay down for quite a while during the day.

August 29, 1916. Child was in bed all day but had a good appetite.

August 30, 1916. Felt better to-day.

August 31, 1916. Had a temperature and complained of pain in the neck. Mother says he has been running wild and eating almost anything

he could get his hands on, such as raw cucumbers and fruit of all kinds. His general condition, therefore, has not been very good. Temperature, by mouth, 101. Neck is moderately rigid. Kernig, positive on both sides but especially on the right side. Knee jerk is exaggerated on the right side, present on the left. There is no history of vomiting. Bowels have been moved thoroughly by two doses of castor oil. Throat is red. Child is rather poorly nourished, very dirty. Spinal fluid pressure 12 mm. which was reduced to 4 by the removal of 30 c.c. of clear fluid. Cell count 80. 10 c.c. of serum were given. The child was sent to the Neighborhood House, Roslyn.

September 7, 1916. 11.30 A.M. Beginning respiratory paralysis noted this morning. Respirations, shallow, frequent (32) labored. Lumbar puncture—20 c.c. of blood-stained fluid removed. Pressure not increased. 2 c.c. of adrenalin hydrochloride (1–1000) was introduced. No improvement during the afternoon. Atropine $\frac{1}{150}$ q. 4 h. 8 P.M. Complete diaphragmatic and intercostal paralysis of left side. Right side accessory respiratory muscles being used. Lumbar puncture: 5 c.c. sanguinous fluid withdrawn. Pressure not increased. Patient died of respiratory paralysis.

Discussion.—This case is one of the dromedary group with a very mild first hump. Puncture a few hours after the second rise in temperature showed only 80 cells. This patient received one intraspinal dose of serum and one of adrenalin. The outstanding features are the low cell count, the poor physical condition of the boy, and the fatal issue.

Case 35.—M. M. Girl. Westbury, L. I.

August 20, 1916. Child developed fever, became irritable and complained of pain in her legs. Had not been well for about a month. Has had no appetite. Previous to this time she has been strong and very active. Child appears ill and has a flushed face. Cries when touched and complains of pain in her ankles when her legs are manipulated. Knee jerks, barely present. Kernig sign, positive. Stiffness of the neck. Temperature 101.2°. Cell count 485 at 18 hours. Refused to send child to the hospital.

August 21, 1916. At 4 P.M. Patient had been admitted to the Roslyn Hospital an hour before. Cell count at this time was 300. Temperature 102.6°. There is more stiffness of the neck and a suggestion of spasticity of the legs. Face is flushed. Child seems quite comfortable, however except when her legs are moved or touched. Cervical lymph nodes enlarged. Spinal puncture. At about 30 hours 25 c.c. of fluid was removed under slightly increased pressure. 15 c.c. of immune serum were injected.

August 22, 1916. 11 A.M. Definite paralysis in the right leg and beginning loss of function of the left. No knee jerks. Child complains of pain in the region of the hip joint when a Kernig is attempted. Cell count 280.

15 c.c. of fluid withdrawn. Spinal pressure is 8 mm. of mercury, measured by the manometer. 15 c.c. of serum injected. Splints applied to the legs to overcome the tendency to toe drop.

August 23, 1916. Condition is advancing. Both legs are paralyzed. Rigidity of the neck more marked. No involvement of the respiratory muscles of the arms. Pressure 9 mm. of mercury, reduced to 1 mm. with the removal of 30 c.c. of spinal fluid. 10 c.c. of immune serum injected. Temperature 102.4°.

August 24, 1916. 4 P.M. Temperature 103°. Patient is cyanotic and breathing with difficulty. There is probably paralysis of the respiratory muscles. Arm is paralyzed. 15 c.c. of fluid withdrawn. Cell count 50. Pressure low. No serum was given.

August 25, 1916. Patient died, apparently of paralysis of the respiratory center.

Discussion.—This patient received her first dose of serum 25 to 30 hours after the onset of symptoms pointing to meningeal invasion. The cells were 485. She pursued a steadily downward course, displaying signs of general prostration in addition to the advancing paralysis. The manner of death was not purely a respiratory muscle failure, but there seemed also to be an additional element of central nature.

Case 36.—M. B. Girl 5½ years. Oyster Bay, L. I.

September 3, 1916. At 11 A.M. Temperature was 105°. Child was drowsy, irritable, constipated, complained of frontal and occipital headache.

September 3, 1916. 3 P.M. Spinal sign positive. Vomiting at 2.30. Temperature 104° per rectum. Headache in the temporal and occipital region. Spinal puncture, within 6 hours, showed a cell count of 240. 15 c.c. of serum given. Child was not quite so apathetic. Spinal sign not quite so positive. Temperature 103.4° at 8 o'clock. At midnight temperature was 100 per rectum.

September 4, 1916. At 8 A.M. Temperature 101.4°. At noon 100.8°. At 4 P.M. 102°. At 5 P.M. 103°. At 5.30 spinal puncture was done. Pressure negative. Cell count 200. 15 c.c. of serum given. There is increase of spine sign and general depression.

September 9, 1916. Patient looks wilted and heavy-eyed, is irritable and rather restless. There is a marked MacEwen's sign. The knee jerks and the ankle jerks are absent. The right biceps jerk is obtained, the left doubtful. Lumbar puncture: about 12 c.c. of clear fluid not under pressure was removed. Cell count 200. Patient is running a high temperature. No paralysis. Slight weakness of the abdominal muscles.

Discussion.—This case with apparent sudden meningeal onset was punctured within the first six hours. Cells were 240. She received two doses of serum. Following the second dose she seemed generally depressed and weak. She recovered with a very slight abdominal weakness.

It is interesting to note that the very marked MacEwen's sign was not associated with increased pressure of the spinal fluid.

Case 37.—H. McC. Girl. 8 years. Freeport, L. I.

August 27, 1916. At 6.30 this morning the patient complained of headache and vomited at 9.30 o'clock. At 11.30 A.M., temperature was 103. At 4 P.M. 102. At 5 P.M. 100.4 per mouth. There was slight pain on flexion of the neck. Pulse 138. No patellar reflexes.

August 28, 1916. *Physical examination* showed the posterior neck muscles slightly rigid. Temperature 101. No other signs present. Spinal puncture at 24 hours showed a slight increase in pressure. Fluid flocculent, not cloudy. Cell count 240. Temperature 102. At 2 P.M. 15 c.c. of serum was given. The cell count was the same as above.

August 29, 1916. Temperature 101. At 10 o'clock 100.8. 15 c.c. of serum was given at 10 A.M. Cell count was not made as child kicked over the tube. General condition of the child much improved. Slept well the night before. Family physician does not think it necessary to repeat the serum, but child will be seen at 9 o'clock to-morrow night, and if necessary serum will be given.

August 30, 1916. At 10 A.M. 15 c.c. of serum was given. Temperature at this time was 100.4.

August 31, 1916. Temperature 99. Child's general condition good.

September 1, 1916. Child has no paralysis and is otherwise in good condition.

Discussion.—Puncture at 24 hours showed 240 cells. The child was very sick. The patient received two doses of serum, 30 c.c. in all.

Case 38.—A. S. Boy. 12 years 9 months. Huntington, L. I.

August 20, 1916. Temperature 105. Child is irritable, constipated, has slight rigidity of the neck muscles, no vomiting and very uncomfortable.

August 21, 1916. Temperature 103. The same symptoms with slight increase of stiffness of the posterior muscles of the neck. Physical examination shows anxious facies. Kernig, slight on the left side. There is a decided spasm of the posterior neck muscles. Child is very irritable, constipated, no vomiting. Spinal puncture, at 24 hours, shows fluid under increased pressure. Cell count 222. 15 c.c. of serum were given.

August 22, 1916. Temperature 103.5.

August 23, 1916. General condition of the patient improved. Slept well night before last. Irritable. Knee jerks, present on the right side. Less spasm of the posterior muscles of the neck. Temperature normal. Appetite fair. Child had a good night. 15 c.c. of serum given. Cell count 70. Fluid came out very slowly, drop by drop. The posterior neck muscles not so stiff. Back flexible. Reflexes positive. No abnormal temperature. Patient had a very slight right lateral abdominal weakness.

Discussion.—This patient had 222 cells at about 24 hours. He received two doses, 30 c.c. Observe the unusual drop in cells following treatment.

Case 39.—C. S. Girl. 5 years. Freeport, L. I.

August 30, 1916. Seen at 1 P.M. when the child complained of headache which she had had during the morning. At 2 P.M. she vomited once. Later on in the afternoon she vomited three times.

August 31, 1916. Temperature, by mouth, 100.6. Neural examination was negative, except for slight pain in the cervical region of the cord when the head was flexed. This symptom was very slight. Spinal puncture at 12 hours, showed a cell count of 170. Pressure was increased. Fluid clear. Child had been sick just 12 hours. 15 c.c. of serum were given.

September 1, 1916. At 10 A.M. Temperature was 101. Cell count 960. 15 c.c. of serum was given. Child complains of no headache and feels much better.

September 2, 1916. No abnormal temperature. Headache has subsided. Child slept well the night before. Appetite was good. Child was up and playing about, so that no serum was deemed advisable. No paralysis.

Discussion.—This patient was not very ill and wanted to get up and play. At 12 hours after the onset puncture showed 170 cells. This patient received two doses of serum, 30 c.c. in all.

Case 40.—F. S. Girl. 15 years. Mineola, L. I.

August 21, 1916. Child complained of vertigo. Restless that night.

August 22, 1916. Child complained of vertigo, headache and nausea. Vomited five times and was constipated. Complains of anorexia. Very severe pain in both legs, from hip down. Temperature 104.6.

August 23, 1916. In the morning complained of cold legs, anorexia, very severe pain in both legs. Vomited, nausea, intense frontal and occipital headache. Posterior neck muscles stiff. Constipated. Nystagmus; ankle clonus on both sides. Double patellar clonus on both sides, also a delayed patellar clonus on both sides. Spinal puncture, at 36 hours, showed fluid under slightly increased pressure. Cell count 130. Temperature 103.6.

August 24, 1916. Temperature 104.8, per mouth. One-half hour later, 104.4 per rectum. Nystagmus and symptoms of the previous day increased in severity. Dr. Dalton gave 15 c.c. of serum at 1 P.M., 60 hours after the onset. Muscles of the lower maxilla stiff. Slight right facial paralysis. Has difficulty in speech, thick and indistinct. Child lay all day in profound stupor.

August 25, 1916. Nystagmus less marked than on the previous day. Slight facial paralysis. Tendo Achilles reflexes positive on both sides. Posterior neck muscles not stiff. Patellar reflexes not decreased. Speech improved, mentally clear. Temperature, per rectum, 104.4. No head-

ache, appetite good. Menstruated this morning seven days ahead of time. Usually has pain and duration of two or three days. No pain this time. Profuse amount. Slight nystagmus.

August 26, 1916. Temperature of the patient is normal. Posterior neck muscles not stiff. Slight facial paralysis of the right side clearing up. Child's speech is now normal. No headache. Complains of a little pain in the right temporal region when she touches it with her hand. Patellar reflexes present on the left side, slightly delayed on the right side. Kernig, negative. Child walks fairly well.

September 1, 1916. Temperature normal. Child up and about. No stiffness of the neck or spinal tenderness. Right facial weakness. Speech normal. Occasional neuralgic pains on the right side of the face. No paralysis of extremities. Tendon reflexes present.

Discussion.—This patient was punctured at about 36 hours following the onset. At this time had 130 cells. She developed profound stupor, nystagmus and slight facial weakness. One dose of serum was given at about 60 hours. Note the menstrual disturbance.

Case 41.—K. McL. Boy. 18 months. Northport, L. I.

August 17, 1917. Child has slight diarrhœa. Sister has the disease.

August 19, 1916. Child in bed sleeping with no history other than the slight diarrhœa for 2 days. Constitutionally he seems well and was awakened for the purpose of examination and temperature. Physical examination at 1 A.M. shows temperature 105. Eyes, ears, nose, throat, heart, lungs, and abdomen normal. Neck and spine stiff and tender. The head will not flex upon the chest. Suspension by the head and buttocks caused arching of the back and pain. Kernig positive in both legs. No paralyses made out in any part of the body. Reflexes normal. Spinal puncture shows clear fluid under normal pressure with a moderate globulin test. Cell count 320. This child was well on going to bed after playing all day. 15 c.c. of serum was given intraspinally after drainage of the cord.

August 20, 1916. At 2.30 P.M. the child seemed better and took food fairly well. Bowels about the same as before. Temperature has dropped to 103. Child seems less toxic.

Note.—Upon the 18th the temperature shows a critical drop to 99. Where it remained for about 8 hours. On the 20th the temperature was 98. Child feels better and shows no paralysis.

August 21, 1916. At 2.30 P.M. Lumbar puncture was performed and the cell count found to be 540. 15 c.c. of serum was given intraspinally.

September 6, 1916. A telephone from the boy's father stated that the boy showed a normal temperature 3 days after he was seen last and that he had made a perfect recovery with no paralysis.

Discussion.—This case is interesting because of the unusual way in which the disease was recognized. The meningeal invasion must have

occurred between the previous evening and 1 A.M., when 320 cells were found. This patient received two doses of serum, 30 c.c. in all. The first treatment was not later than 7 hours after meningeal invasion.

Case 42.—C. W. Boy. 4½ years. Lawrence, L. I.

September 6, 1916. Appetite poor but seemed to have no temperature. His bowels moved and he complained of no pain or other distress. His mother says he did not seem very ill during this period, though not quite himself.

September 9, 1916. After eating tomatoes the child suffered an abrupt rise in temperature which has remained until he was seen by physician.

September 10, 1916. Was seen by physician at noon. Temperature 103. Has vomited on three or four occasions after taking food. Bowels have been constipated. Has no cold in the head, cough, sore throat, pain in the chest, abdomen, or joints. He has had no earache. Mother thought the child favored his neck in movements. No history of a rise in temperature previous to 4 days ago. Physical examination shows temperature 103. Eyes, ears, nose and throat negative. Cervical glands normal. Neck slightly stiff and tender, cannot place chin on the chest. Suspension by head and buttocks shows the neck and back to be straight. Heart, lungs and abdomen normal. No paralyses are made out. Knee jerks are present. Kernig is absent. Spinal puncture, at 30 hours, 15 c.c. of cloudy fluid withdrawn. Cell count 280. No red cells. Globulin +. 5 c.c. of serum injected slowly.

September 11, 1916. Temperature 104. Child had had a restless night. Has vomited incessantly. Bowels have not moved. Mother noticed much twitching of the eye, eyelids and hands; she thinks he is much worse. Physical examination shows the child looks worse, more toxic. Lips and tongue dry and cracked. Left eye seems to be turned slightly inward, although all movements of both eyes are obtainable. The neck is the same as on the last visit. Knee jerks very active. Kernig positive in both legs with pain. Paralyses other than the left external rectus are not present. Child is to be removed immediately to the hospital, and further serum treatment though indicated is postponed until his arrival there. A second dose of serum was given. Following this the patient became much worse, there being intense meningismus and opisthotonos. Child very toxic. Twenty-four hours after the second dose, the patient appeared to be going to die, but his condition changed and rapidly improved and he had a normal temperature in 5 days. There remained a weakness of the masseters and slight deglutition weakness.

Discussion.—This patient seemed to become much worse following treatment, very toxic and showing intense meningismus. His ultimate recovery was good with slight weakness. The first treatment was about 30 hours following the second hump onset. The cells were then 280.

Case 43.—W. C. Boy. 4 years. Inwood, L. I.

August 24, 1916. This afternoon the patient complained of not feeling well. Did not want to play. Did not have any pain. No vomiting. Bowels moved only after medicine. Temperature 101. Pulse 150. Pupils unequal, slow in reacting. Child apathetic and hyperæsthetic. Knee jerks present, but slight. Kernig slight. Neck stiff and painful. Lumbar puncture at 8 hours shows clear fluid under pressure. Cell count 215.

August 25, 1915. Temperature 101. Child said to be about the same as above. The neck and back are stiff and tender with a considerable retraction of the former. There is no Kernig or paralysis. Child appears toxic and definitely of the meningeal type. Spinal puncture. 15 c.c. clear fluid were withdrawn. Cell count 150. 15 c.c. of reddish serum from a cured case received from Willard Parker injected into the spine.

August 26, 1916. 12.30 P.M. Temperature 101. Child appears to be more toxic and considerably worse than the day before. Has had two or three greenish, watery movements, which show undigested grape and pear. He vomited once after serum injection; it was not projectile in type. Physical examination shows neck and back markedly retracted. Kernig marked. Lips and tongue are very dry and cracked. Child is very toxic. No paralysis. Spinal puncture. 15 c.c. of very cloudy fluid obtained. There is no evidence of reddish color. Cell count 5600. Leukocytes present. No red cells. Globulin +++. Differential count: Polynuclears 81 per cent., lymphocytes 19 per cent. Film stained by Gram stain shows no organism. Culture remained sterile 48 hours. 15 c.c. of serum injected intraspinally.

August 27, 1916. Temperature 100. Child much better. Stiffness of the neck and retraction. Kernig present, but less marked. No paralysis. Bowels better. Appetite good. Cord tapped and drained. 15 c.c. of clear fluid. Globulin +. Cell count 580. No serum injected.

August 29, 1916. Child improved. Temperature 99. Neck slightly stiff.

August 31, 1916. Neck slightly tender, otherwise normal. Temperature 98. No paralysis.

September 8, 1916. General condition good. Up in wheeled chair. Slight weakness of legs. When walking there is a slight give at the knees. Knee jerks present.

September 15, 1916. Interossei and lumbricales of the right hand paralyzed and slight claw-like contracture.

Discussion.—The initial puncture in this case was made about 8 hours after the onset of symptoms and shows 215 cells. The child was very ill. At 26 hours a second puncture was done, showing 150 cells. 15 c.c. of serum were given. Note the increase of cells to 5600 following this procedure, and also the marked opisthotonos. After the second injection the

cells dropped to 580. This patient, as many others, became much more acutely ill following the intraspinal injection.

Case 44.—G. S. Boy. 6½ years. Northport, L. I.

September 11, 1916. Patient at this time vomited. Temperature 102, lasting 12 hours. Constipated. Then well until the 18th, a 7-day interval.

September 19, 1916. Patient complained of pain in the right leg and headache. Temperature 101.5. Right knee jerk exaggerated. Slight rigidity of the neck. Physical examination shows: temperature 101.5. Muscle tenderness of both thighs. Spine sign present. Reflexes normal. Lumbar puncture, at 17 hours, pressure increased. Cell count 270. Globulin + −. 10 c.c. serum given.

September 20, 1916. Temperature 102. Spine sign present. Double Kernig. Stiff neck. Lumbar puncture: fluid turbid under pressure. Cell count 300. Acute retention. Relieved by catheterization. 15 c.c. of serum given.

September 21, 1916. Temperature normal. No weakness or paralysis. Voided spontaneously.

September 29, 1916. Child up and about the ward. No paralysis or weakness.

Discussion.—This case was treated 17 hours after the onset of the second hump. There were then 270 cells. No further treatment was given. The unusual length of the free interval is a striking feature of the case.

Case 45.—A. H. Boy. 2½ years. Westbury, L. I.

September 15, 1916. Patient had a temperature of 104. Tonsils enlarged and red with white spots. Lumbar puncture was done at this time. Pressure was normal. Cell count 5. Temperature was normal for 3 days following.

September 18, 1916. A colitis came on and the patient's temperature rose again, reaching 104.

September 20, 1916. Temperature 103. No spine sign. Reflexes normal. Tonsils normal. Lumbar puncture was done at 48 hours and slightly increased pressure was found. Cell count 39. Globulin +. No weakness of any muscles.

September 21, 1916. Physical examination shows weakness of the right deltoid. Spine sign present. Neck quite stiff. Temperature normal. Lumbar puncture: pressure +. 30 c.c. of fluid were withdrawn. Cell count 33. 10 c.c. of serum were given.

September 22, 1916. Temperature last night was 101. Temperature this morning was 99. Spine sign still marked. Right arm weaker than yesterday. Knee jerk and Achilles slightly increased. No other paralysis. Lumbar puncture: fluid, pressure +. 10 c.c. of serum given. Child to be sent to the Garden City Hospital to-day.

September 25, 1916. Temperature normal since last night. Paralysis

of the right arm marked. Slight weakness of the anterior tibial muscles on one side.

Discussion.—This case belongs to the dromedary group, but the stage of meningeal invasion is not sharply marked, nor are the signs of meningeal invasion great. The first puncture, at 48 hours after the second onset showed 39 cells and no serum was given in consequence. The next day weakness of the right deltoid appeared. Two doses of serum were then given, 20 c.c. in all. There was no doubt that the serum was delayed in this case owing to the very slight reaction found in the spinal fluid at the first puncture.

A REPORT OF TWENTY-SIX CASES

By Drs. Amoss and Chesney

From *Journ. of Exp. Med.*, 1917, xxv, 581

Group I. Cases Showing Paralysis at the Beginning of the Treatment

Class I. Paralysis Extending

Case 1.—Male. Age 33 years.

September 2, 1916. Malaise, headache, and vomiting. Sept. 3. Unable to bear weight on legs. Sept. 4. Admitted to hospital. Legs completely paralyzed. No tendon reflexes. Cerebrospinal fluid shows 280 cells per c.mm. and increased globulin. Bladder, bowels, diaphragm, abdominal and thoracic walls, and upper extremities normal. Sept. 5. Bladder paralyzed; no abdominal movement during respiration; using accessory muscles of respiration; deltoids weak; cyanosis.

On Sept. 5, 10 c.c. of serum were injected intraspinally and 20 c.c. intravenously. The cyanosis gradually increased, and death resulted from respiratory paralysis 10 hours after the injection. No obvious influence on the course of the disease was exerted by the injections of serum.

Case 2.—Female. Age 10 years.

September 22, 1916. Headache, nausea, fever, and abdominal pain. Sept. 23. Temperature 103°F. Pain in back and in right leg; drags right foot. Sept. 25. Admitted to hospital. Temperature 102.6°F.; pulse 112; respirations 30. Neck and back muscles stiff; flaccid paralysis of both legs; bladder functions. Sept. 26, 6 P.M. Left deltoid paralyzed; dyspnoeic; employs accessory muscles of respiration; no respiratory movement of abdominal wall; bladder paralyzed. Cerebrospinal fluid contains 270 cells per c.mm.; globulin increased.

On Sept. 26, 20 c.c. of serum were given intraspinally and 60 c.c. subcutaneously. Sept. 27, 8 P.M. Temperature 99.8°F.; pulse 102; respirations 30. Abdominal muscles move with respiration. Sept. 28. Abdomen moves freely; left deltoid responds but not yet normally; bladder inactive. Sept. 30. Bladder acting; no change in leg condition.

The history of the acute stage of this case readily divides itself into two periods. The first (*a*) takes in the time up to and including the paralysis

of the legs, followed by a brief interval when (*b*) the abdomen, diaphragm, shoulder, and bladder became paralyzed. It was during the second period that the serum was administered. Coincidently with the administration there was no further progress, but rather a rapid recession of the recent paralysis; the older paralytic condition was not obviously affected. Whether the phenomena described are of the nature of cause and effect cannot certainly be determined.

Case 3.—Male. Age 3 years.

September 26, 1916. Fever and vomiting. Sept. 27. Difficulty in swallowing. Sept. 28. Admitted to hospital. Temperature 101°F.; pulse 112; respirations 38. Paralysis of muscles of deglutition. Sept. 29. Complete paralysis of right side of face. 12 M. Temperature 104.2°F.; pulse 138; respirations 62. Very ill. 2 P.M. Cerebrospinal fluid, 208 cells per c.mm.; globulin slightly increased.

On Sept. 29, 15 c.c. of serum were administered intraspinally, 20 c.c. intravenously, and 40 c.c. subcutaneously. Sept. 30. Temperature 99°F.; pulse 102; respirations 68. Marked improvement in general condition but no change in the degree of paralysis of the face or muscles of deglutition. Before discharge the paralysis had almost disappeared.

Whether the prompt subsidence of the severe general symptoms in this case is to be ascribed to the serum treatment cannot be stated positively. The fact that no extension of the paralysis occurred in spite of the severe symptoms may or may not have been due to the treatment. But in this instance, as in Case 2, the paralysis was extending at the time the serum was given and no further extension occurred. It is obvious that in the first case of this series, no result was accomplished. It should be mentioned, however, that as compared with the more energetic treatment subsequently employed that case received a very small quantity of the serum, which was administered late in the course of the disease.

Class II. Paralysis Present

Case 4.—Female. Age 33 years.

October 16, 1916. Chilly sensations; abdominal pain; difficulty in walking. Oct. 17. Stiffness of neck; legs weak. Oct. 18. Admitted to hospital. Temperature 103°F.; pulse 104; respirations 34. Neck and back stiff; weakness of muscles of abdomen and left leg. None of the muscle groups are completely paralyzed. Cerebrospinal fluid, 50 cells per c.mm.; globulin increased.

On Oct. 18, 20 c.c. of serum were given intraspinally and 50 c.c. intravenously. Oct. 19. Paralysis stationary. Oct. 21. Temperature 99.6°F. No extension of the paralysis.

The serum was administered in this case probably within 24 hours of the onset of definite paralysis, but whether or not it influenced the progress cannot be stated.

Case 5.—Male. Age 2 years.

September 13, 1916. Fever and headache. Sept. 18. After an apparently normal interval, vomiting occurred and the neck and back became stiff. Sept. 20. Weakness of legs noticed. Admitted to hospital. Temperature 98.2°F.; pulse 108; respirations 44. Neck and back stiff; face slightly asymmetrical; abdominal wall relaxed; no reflexes; partial paralysis of muscles of legs. Cerebrospinal fluid, 37 cells per c.mm.; globulin increased.

On Sept. 20, 5 c.c. of serum were given intraspinally and 30 c.c. subcutaneously. The paralysis did not extend, but there was no immediate improvement of the paralyzed muscles.

The treatment in this case was given probably at the end of the 4th day of illness at a time when the paralysis had already been arrested. Apparently nothing definite was accomplished. Case 6, a sister of this patient, should be used for comparison.

Case 6.—Female. Age 4 years.

September 19, 1916. Fever, headache, and constipation. Sept. 20. Temperature 101.4°F.; vomiting. Facial asymmetry. 11 P.M. Admitted to hospital. Temperature 102°F.; pulse 140; respirations 32. Neck and back stiff; slight left facial paralysis; weak hamstring and quadriceps muscles on both sides; knee jerks and Achilles tendon reflexes increased. Cerebrospinal fluid cloudy and contains 920 cells per c.mm.; globulin increased.

On Sept. 20, 10 c.c. of serum were given intraspinally and 25 c.c. subcutaneously. Sept. 22. No extension of paralysis. Sept. 23. Temperature normal.

In this case the serum was given within 30 hours of the onset of the symptoms and at a time when weakness of the muscles of the thighs was appearing. The temperature became normal in about 60 hours and no extension of the paralysis ensued. Within 2 weeks recovery of all the weak muscles was complete. The striking point in the case is the large number of cells in the cerebrospinal fluid when the serum was injected.

Case 7.—Female. Age 2 years.

September 12, 1916. Headache and fretfulness. Sept. 14. Admitted to hospital. Temperature 101.8°F.; pulse 124; respirations 28. Weakness of flexors and extensors of right hip and of gastrocnemius. Achilles tendon reflexes absent. Cerebrospinal fluid contains 99 cells per c.mm. and increased globulin.

On Sept. 14, 5 c.c. of serum were injected intraspinally and 30 c.c. subcutaneously. Sept. 15. Temperature normal; paralysis stationary. There was never any extension, but gradual improvement of the partially paralyzed muscles. The temperature curve shown in Text-fig. 18.

Case 8.—Male. Age 22 months.

September 9, 1916. Child ill. Sept. 10. Admitted to hospital. Temperature 102.6°F.; pulse 136; respirations 36. Weakness of left quadriceps anterior.

On Sept. 10, 5 c.c. of serum were administered intraspinally at home before removal to the hospital. Sept. 11. Left thigh muscles weaker. 20 c.c. of serum given subcutaneously. Sept. 13. Temperature normal. Partial paralysis unchanged.

Case 9.—Female. Age 3 years.

October 12, 1916. Child feverish and irritable. Oct. 14. Left leg partially paralyzed. Oct. 15. Admitted to hospital. Temperature 99.8°F.; pulse 120; respirations 32. There is stiffness of the neck and back, weakness of the extensors of the left foot, and toe-drop. Cerebrospinal fluid contains 115 cells per c.mm.; globulin increased.

On Oct. 15, 15 c.c. of serum were injected intraspinally and 40 c.c. subcutaneously. The temperature fluctuated irregularly between 98.6° and 100°F. for 2 weeks. The weakness of the foot and leg increased somewhat. One month later some degree of impairment was present in the left quadriceps, hamstrings, peroneals, and toe extensors, while the anterior tibial group was completely paralyzed.

The serum was injected in this case within about 72 hours of the first appearance of any symptoms and at a time when only slight and limited paralysis existed. Nevertheless, the muscular impairment progressed slowly in the muscles first affected and into neighboring muscles, but the degree of paralysis never became severe.

Case 10.—Male. Age 15 months.

September 9, 1916. Child feverish and sweating; vomited. Admitted on same day. Temperature 99.6°F.; pulse 132; respirations 36. The neck and back are stiff and there is doubtful weakness of the right deltoid. Cerebrospinal fluid shows 30 cells per c.mm.; globulin increased.

On September 9.5 c.c. of serum were given intraspinally. There was no further involvement of the right deltoid and the temperature remained normal during the stay in the hospital.

This child was seen within a few hours of the onset of the first symptoms and the serum injection was given at the home before removal to the hospital. No paralysis developed.

Case 11.—Female. Age 2 years.

September 27, 1916. At noon the child was feverish. 10 P.M. Stiffness of the neck and back, weakness of the left quadriceps and peroneal muscles, and slight weakness of the intercostals. The patient, whose brother was already in the hospital, was admitted at once. Temperature 101°F.; pulse 110; respirations 32. Cerebrospinal fluid, 30 cells per c.mm.; globulin increased.

On Sept. 27, 10 c.c. of serum were given intraspinally and 30 c.c. subcutaneously. Sept. 28. After 24 hours the temperature was 100°F.; no extension of muscular weakness. Sept. 29. Temperature normal. Muscular impairment gone. No abnormality on discharge.

The serum was administered to this child within 12 hours of the first appearance of the symptoms, and although a degree of weakness of certain muscles was already present, it quickly disappeared.

Case 12.—Male. Age 3½ years.

September 12, 1916. Headache and fever. Sept. 13. Temperature 103.8°F. Stiffness of neck and back; weakness of muscles of right ankle; toe-drop. Cerebrospinal fluid, 250 cells per c.mm.; globulin increased.

On Sept. 13, 10 c.c. of serum were injected subdurally and 40 c.c. subcutaneously. Sept. 14. Temperature 99.6°F. Weakness of muscles diminished rapidly.

The serum was administered within 24 hours of the onset of symptoms and at a time when several muscle groups were impaired. The temperature quickly fell to normal and the muscular weakness soon disappeared.

In considering Cases 1 to 12 the points that can be made definitely are: (1) the diagnosis was clearly established in each; (2) there was some grade of paralysis present in each; and (3) with the exception of Case 1, 8 and 9, there was either no increase of the existing muscular weakness or paralysis, or there was prompt improvement in these conditions.

Group II. No Paralysis at the Time of Treatment

In the following series of fourteen cases, no paralysis was detected up to the time that the serum was administered. One reservation should, however, be made: in the early stages of the disease, some of the patients were too ill to warrant a full examination of all the muscle groups and hence a degree of weakness or paralysis may have sometimes been overlooked. Moreover, the quantity of serum administered varied considerably, depending upon circumstances. The cases will be considered in the order of the amounts of serum given.

Case 13.—Male. Age 8 years.

September 19, 1916. Headache, fever, and drowsiness. Sept. 20. Same condition; neck and back stiff. Sept. 21. Admitted to hospital. No paralysis detected. Temperature 102.5°F.; pulse 102; respirations 32. Cerebrospinal fluid, 850 cells per c.mm.; globulin increased.

On Sept. 21, 5 c.c. of serum were given intraspinally and 15 c.c. subcutaneously. Sept. 24. Temperature normal. In the interim weakness of the following muscle groups developed: deltoids, pectorales, major rotators (outward) of arms, flexors of hip, quadriceps and hamstrings, and abdominal wall.

The serum was administered within 48 hours of the onset of symptoms.

The amount given intraspinally was small. Weakness subsequently developed in many muscle groups, but in none was the paralysis complete.

Case 14.—Male. Age 19 months.

September 19, 1916. Vomiting, attributed to improper food. Sept. 20. Fever; neck and back stiff; muscular twitchings. Admitted to hospital. Temperature 103°F.; pulse 124; respirations 32. While there was muscular stiffness, no weakness was detected. Cerebrospinal fluid, 120 cells per c.mm.

On Sept. 20, 5 c.c. of serum were injected intraspinally and 20 c.c. subcutaneously. The fever persisted, and paralysis developed, involving ultimately the muscles of respiration. Sept. 23. Died.

Obviously no influence on the course of the disease was exerted by the serum. The experience gained later now indicates that the injection should have been repeated.

Case 15.—Female. Age 4 years.

September 23, 1916. Fever and headache; irritable. Sept. 24. Neck and back stiff; muscular twitching. Admitted to hospital. Temperature 103.6°F.; pulse 128; respirations 34. No muscular impairment detected. Cerebrospinal fluid, 360 cells per c.mm.; globulin increased.

On Sept. 24, 10 c.c. of serum were given intraspinally and 20 c.c. subcutaneously. Sept. 25. Flaccid paralysis of right arm and shoulder girdle with rapid extension and involvement of muscles of respiration. Died.

Autopsy showed severe poliomyelitic lesions of the cervical cord and medulla.

Obviously this case was not benefited by the serum injection, since paralysis developed a few hours after the treatment and extended rapidly.

Case 16.—Female. Age 8 years.

September 23, 1916. Headache; restless. Sept. 24. Temperature 102°F. Neck stiff. Cerebrospinal fluid, 730 cells per c.mm.; globulin increased.

Within 6 hours of the onset 10 c.c. of serum were administered intraspinally and 20 c.c. subcutaneously. The temperature fell slowly and reached normal on the fourth day. During this period weakness of the muscles of both arms and possibly slight weakness of the left leg appeared; complete paralysis was never present. Improvement was rapid, and almost complete recovery of lost strength was made in a short time.

Case 17.—Female. Age 2 years.

September 17, 1916. Fever; drowsy; muscular twitching; convulsions. Sept. 19. Admitted to hospital. Cerebrospinal fluid, 60 cells per c.mm.; globulin increased. Temperature 104.2°F.; pulse 132; respirations 32. Neck and back stiff; no muscular weakness.

On September 19, 6 c.c. of serum were given intraspinally and 25 c.c.

subcutaneously. Within 24 hours the temperature was normal. No muscular weakness developed.

Case 18.—Male. Age 5 years.

September 14, 1916. Temperature 103°F.; headache; drowsy. Sept. 15. Neck and back stiff. Temperature 104°F. Admitted to hospital. Temperature 103.4°F.; pulse 126; respirations 50. No weakness of muscles. Cerebrospinal fluid, 379 cells per c.mm.; globulin increased.

Within 24 hours of the onset 5 c.c. of serum were given intraspinally and 25 c.c. subcutaneously. Sept. 16. Temperature 101°F. 5 c.c. of serum were introduced intraspinally. Cerebrospinal fluid, 249 cells per c.mm. Sept. 17. Temperature normal. No muscular weakness ever developed.

Case 19.—Male. Age 4 years.

September 17, 1916. Temperature 102°F.; pain in back. Sept. 19. Temperature 102.4°F. Neck and back stiff. Cerebrospinal fluid, 150 cells per c.mm.; increased globulin. Admitted within 24 hours of onset.

On Sept. 18, 10 c.c. of serum were injected intraspinally and 25 c.c. subcutaneously. 15 hours later the temperature became normal. No muscular weakness developed.

Case 20.—Male. Age 13 months. Cousin of Case 19.

September 17, 1916. Drowsiness and fever. September 18. Cerebrospinal fluid clear and contains 75 cells per c.mm.; globulin increased. The patient was given 10 c.c. of serum subdurally and was shortly afterward brought to the hospital. On admission, temperature 101.4°F.; pulse 120; respirations 26.

Immediately after admission a subcutaneous injection of 25 c.c. of serum was given. The temperature rose to 104°F. and fell to normal 22 hours afterward. There was no subsequent weakness or paralysis.

This patient was treated about 18 hours after the first symptoms. The temperature previous to treatment is not known. After a rise to 104°F. the temperature fell rapidly, reaching normal about 22 hours after the first injection (Text-fig. 17). The child developed no subsequent weakness or paralysis.

Case 21.—Female. Age 3½ years.

September 3, 1916. Headache; temperature 102°F. September 4. Temperature 104°F. September 5. Temperature 101.5°F. Stiffness of neck. September 6. Cerebrospinal fluid clear and contains 230 cells per c.mm.; globulin increased. Admitted to hospital the same afternoon. On admission, temperature 102.4°F.; pulse 130; respirations 42. Stiffness of neck and back; no weakness or paralysis noted.

Immediately after admission 5 c.c. of serum were injected subdurally and 40 c.c. subcutaneously. Temperature reached normal 32 hours after treatment. No definite weakness or paralysis developed subsequently.

In this case treatment was begun about 3 days after the initial symptoms and at a time when paralysis had not appeared. Treatment was followed

by a rapid drop in temperature and no weakness or paralysis developed during the period of observation.

Case 22.—Female. Age 3½ years.

October 7, 1916. Fatigue, irritability, and vomiting. October 8. Fever and a mild delirium. October 10. Fever persisted; drowsiness. Admitted to hospital. On admission, temperature 101.6°F.; pulse 132; respirations 28. Stiffness of neck and back. Clear cerebrospinal fluid with 88 cells per c.mm.

On October 10, 20 c.c. of serum were injected subdurally and 30 c.c. subcutaneously. Temperature rose to 104°F. that night and there was slight nystagmus. Lumbar puncture yielded a slightly turbid fluid under considerable pressure. About 30 c.c. of fluid were withdrawn from the spinal canal. On the following morning the nystagmus had disappeared and 36 hours after treatment the temperature reached normal. Cultures of the turbid fluid were sterile. Turbidity was due to the presence of a large number of polymorphonuclear leukocytes. No weakness or paralysis developed subsequent to treatment.

This patient was treated 3 days after the initial symptoms when there was no evidence of weakness or paralysis. Following the treatment there was evidence of increased irritation of the meninges and increased pressure in the subdural space which was relieved by lumbar puncture and withdrawal of fluid. The temperature reached normal 36 hours after the injection and the child did not develop any weakness or paralysis subsequently. The serum used in this case contained considerable fat; whether or not this played a part in the reaction following the injection cannot be stated definitely. This was the only instance in which any such reaction was obtained, although other cases were treated with portions of the same serum.

Case 23.—Male. Age 5 years.

October 3, 1916. Vomiting. October 4. Fever; vomiting persisted. Clear cerebrospinal fluid with 250 cells per c.mm. Admitted to hospital. On admission, temperature 101°F.; pulse 130; respirations 30. Stiffness of neck and back; no weakness or paralysis.

15 c.c. of serum were immediately given subdurally and 40 c.c. subcutaneously. Temperature rose to 103°F. and fell to normal 12 hours later. There was no subsequent weakness or paralysis.

This patient was treated about 30 hours after what seemed to be the initial symptoms. At the time of treatment there was no demonstrable involvement of any muscle group. The temperature dropped to normal 12 hours after treatment and the child did not show any weakness or paralysis at any time.

Case 24.—Female. Age 1½ years.

October 11, 1916. Temperature 101°F. October 12. Stiffness of the neck and back with muscle tenderness. Temperature 103°F. No

demonstrable weakness. Admitted to hospital. On admission, temperature 103°F.; pulse 118; respirations 28. Clear cerebrospinal fluid with 40 cells per c.mm.; globulin increased.

On October 12, 25 c.c. of serum were injected subdurally and 35 c.c. subcutaneously. Temperature dropped to normal within 16 hours after treatment. At no time was there any demonstrable weakness present.

This patient was treated about 30 hours after the mother first noticed fever, and at a time when there was no demonstrable weakness of any muscles. The temperature became normal in less than 24 hours after treatment. An older sister of this patient was admitted to the hospital on the day previous to the one on which this case was admitted. The sister had been sick for a period of 4 days with temperature as high as 104°F. She was admitted at the end of the febrile period, 4 days after the onset, and at the time of admission lumbar puncture showed the presence of a clear fluid with 76 cells and increased globulin. She received no serum and developed no weakness or paralysis.

Case 25.—Male. Age 5 years.

October 5, 1916. Irritability and fever. October 6. Fever persisted; constipation. October 7. Admitted to hospital. On admission, temperature 103°F.; pulse 104; respirations 28. Marked stiffness of neck and back; active reflexes; positive Kernig. No demonstrable weakness of any muscle group. Clear cerebrospinal fluid with 260 cells per c.mm.; globulin increased.

On October 7, 22 c.c. of serum were given subdurally and 45 c.c. subcutaneously. The temperature fell to normal within 22 hours after treatment and the patient did not develop any weakness or paralysis.

This patient was treated about 48 hours after onset of the first symptoms and within 22 hours after treatment the temperature was normal (Text-fig. 19). No weakness or paralysis developed. A younger sister of this patient was admitted to the hospital 2 days previously with flaccid paralysis of both lower extremities. In this case onset had occurred 5 days before admission and the temperature had fallen to normal and paralysis had already set in when she was admitted.

Case 26.—Male. Age 23 years.

December 9, 1916. Vomiting and headache. Stiffness of neck, hyperæsthesia, and asymmetry of patellar reflexes. Kernig's sign present on right side. Temperature 101°F. No demonstrable weakness of any muscle group. Clear cerebrospinal fluid with 40 cells per c.mm.; globulin increased.

38 hours after onset patient received 20 c.c. of serum subdurally and 100 c.c. intravenously. Following treatment the temperature fell to normal within 48 hours, the hyperæsthesia disappeared within that time, and no paralysis or weakness developed.

This patient, an adult, was treated within 38 hours after the initial

symptoms at a time when there was no demonstrable involvement of the muscles. His temperature rapidly fell to normal, and no weakness or paralysis developed subsequently.

The more important facts relating to the twenty-six cases described are collected in Table I.

REFERENCES

[1] Micheal Underwood: Treatise on Diseases of Children, Phila., 1793.

[2] John Badham: London Med. Gazette, 1835, XVII, 215.

[3] Jac. v. Heine, Stuttgart, 1840.

[4] A. Strumpell: Deutsch. Arch. f. Klin. Med., 1891, 47–53.

[5] Medin: Arch. med. des enfants, 1898, 1–257, 321.

[6] Wickman, Berlin, 1905.

[7] Müller, Berlin, 1910.

[8] Zappert, Wiesner and Leiner, Leipsic & Wein, 1911.

[9] Provost and Vulpian: Compt. rend. de la Soc. de Biol., 1865.

[10] Charcot and Joffroy: Archives de physiologie normale et pathologique, 1870.

[11] Roger and Damesceno: Compt. rend. de la Soc. de Biol., 1871.

[12] Rissler: Nord. Med. Ark., 1888, XX, 1.

[13] Wickman: *Loc. cit.*

[14] Strauss: The Pathology of Acute Poliomyelitis. Rep. of Collective Investigation Comm. on the New York Epidemic of 1907, p. 68.

[15] Harbitz and Scheel: Pathologisch-anatomische untersuchungen über akute Poliomyelitis, Christiana, 1907.

[16] Wickman: Die Akute Poliomyelitis, etc., Handbuch der neurologie, Berlin, 1911.

[16a] Flexner, Peabody and Draper: Journ. Am. Med. Ass'n, 1912.

[17] Landsteiner and Popper: Zeitschr. f. Immunitats forsch. Orig., 1909, 11, 377.

[18] Flexner and Lewis: Journ. Am. Med. Ass'n, 1909, III, 2095.

[19] Landsteiner and Levaditi: Compt. Rend. Soc. de Biol., 1909, 7, XVI, 592.

[20] Leiner and von Wiesner: Wien. Klin. Wochenschr, 1909, XXII, 1698.

[21] Landsteiner and Levaditi: Compt. rend. Soc. de Biol., 1910, LXVIII, 311.

[22] Flexner and Lewis: Journ. Am. Med. Ass'n, 1909, LIII, 1639.

[23] Flexner and Noguchi: Journ. Exp. Med., 1913, XVIII, 461.

[24] R. W. Lovett and M. W. Richardson: Bull. Mass. State Med. Bd. of Health, 1911, p. 55.

[25] C. S. Caverly: Bull. Vermont State Bd. of Health, 1914, XIV, 3.

[26] Report of Med. Director of Mayor's Special Comm., 1917.

[27] H. L. Amoss and Ed. Taylor: Journ. Exp. Med. 1917, XXV, 507.

[28] Mathers, G.: Journ. Am. Med. Ass'n., 1916, XVII, 1019. Journ. Infectious Diseases, 1917, XX, 113.

[29] Rosenow, E. C., Towne, E. B. and Wheeler, G. W.: Journ. Am. Med. Ass'n, 1916, XVII, 1202.
[30] Phil. A. E. Sheppard: N. Y. State Journ. of Med., 1916, XVI, 442.
[31] Report of New York City Department of Health, 1917.
[32] Flexner, Clark and Frazier: Journ. Am. Med. Ass'n, 1913, LX, No. 3.
[33] Kling, Pettersson and Wernstedt: Rep. of State Med. Institution of Sweden to XVth International Congress on Hygiene and Demography, Washington, 1912.
[34] Kling, Pettersson and Wernstedt: *Loc. cit.*
[35] Flexner and Amoss: Journ. Exp. Med., 1917, XXV, 539.
[36] Flexner and Amoss: Journ. Exp. Med., 1914, XX, 249.
[37] Flexner and Amoss: Journ. Exp. Med., 1917, XXV, 525.
[39] Flexner and Lewis: Journ. Am. Med. Ass'n, 1910, LIV, 45.
[40] Netter, Jendron and Touraine: Compt. Rend. des Séance de la Soc. di Biologie, 1911, 70, 625.
[41] Netter, A.: Bull. Acad. Med., 1915, LXXIV, series 3, 403.
[42] Netter, A.: and Salanier, M., Bull. et mém. Soc. méd. hôp., Paris, 1916, XL, series 3, 299.
[43] Römer and Joseph: Munch. Med. Woch., 1910, LVII, 568.
[44] Levaditi and Landsteiner: Compt. Rendu. Soc. Biol., 1910, LXVIII, 311.
[45] Flexner and Lewis: Journ. Am. Med. Ass'n, 1910, LIV, 1780 and LV, 662.
[46] Blanton, W. B.: Journ. of Med. Research, 1917, XXXVI, 1.
[47] Amoss and Chesney: Journ. Exp. Med., 1917, XXV, 581.
[48] Zingher, Abraham: Journ. Am. Med. Ass'n, 1917, LXVIII, 817.
[49] Anderson, J. F.: and Frost, W. H.: J. Am. Med. Ass'n, 1911, LVI, 663.
[50] Zingher, A.: Journ. Am. Med. Ass'n, 1917, LXVIII, 817.
[51] Peabody, F. W.: Boston Med. Surg. Journ., 1917.
[52] Mott: Lancet, London, 1910, II, 79.
[53] Flexner, S.: Journ. Am. Med. Ass'n, 1913, LXI, 447 and 1872.

INDEX

A

After care, 103
Ataxia, 64

B

Badham, John, 1
Blood, 70
  differential count, 70
  virus in, 25
Bone marrow, virus in, 25

C

Carriers, 16, 20
  barnyard fowls, 20
  healthy, 16
  insects, 20
  pet animals, 20
  rodents, 20
Case reports 44–61, 103–145
  diagnostic series, 44–61
  treatment series, 103–145
Cases, mild, 67
Cell count, 71
  prognostic significance, 72, 73
Cerebrospinal fluid during systemic phase, 71
  cell count, 71
  globulin, 71
  lange colloidal gold, 71
  types of cells, 71
  Wassermann reaction, 71
Charcot, 3
Choroid plexus, 26
Clinical classification 38, 42, 43
  dromedary type, 40
  straggling type, 40
  sudden onset type, 40
Constipation, 69
Culture media, 29

D

Damescino, 3
Diagnosis of paralysis, 78
Diagnostic series, 44–61
Diarrhœa, 62
Draper, 3
Drowsiness, 67

E

Emotional instability, 76
Epidemiology, 13
  group immunity, 20
  milk and food, 22
  seasonal occurrences, 17, 18
  winter epidemic, 19
Etiology, 6
Expression, 63
Eyes, 63

F

Family susceptibility, 10
Fever, 62, 65, 69
Flexner, 4, 28

G

Globoid bodies, 29
Globulin, 71

H

Harbitz, 3
Heine, 1
Hospitalization, 87

I

Immune serum, 28
  Flexner, 28
  Lewis, 28
  Netter, 28
  neutralization test, 28

Immune serum, human, 88
hemoglobin, 88
preparation, 88
red cells, 88
Immunity, active, 28
acquired, 28
passive, 28
Immunity, group, 20
Immunity of previously infected areas, 21
Infection, propagation of, 4
Infections, contact, 14, 15, 19
group, 14, 15
Injection, time of intraspinal, 100
Isolation, 4

I

Joffroy, 3

K

Kissing, 87

L

Landersteiner, 4
Lange gold test, 71
Leiner, 4
Levaditi, 4
Lovette, 103
Lumbar puncture, 88
technique, 88
multiple, 41, 66
Lymph nodes, 68

M

Medin, 2
Meningo-choroid defense, 26
Monkeys, transfer to, 4
Müller, 3
Muscular twitching, 64

N

Nasal irrigation, 85
Netter, 28
Neurophage, 31
Neutralization test, 28
Noguchi, 4

O

Opisthotomes, 67
Organism, the, 4, 11
cultivation and isolation, 4
Oxydase reaction, 35

P

Pain, 68
Paralysis, 75
as central thought, 4
diagnosis, 78
prognosis, 81
progressive, 76
respiratory muscles, 78, 80
Pathology, 30
in experimental disease, 30
in human disease, 35
parenchymatous lesions, 31
Peabody, 3
Pharynx, inflammation of, 62
mucous membrane of, 25
Popper, 4
Prognosis, 81
psychic state in relation to, 82
value of spinal fluid in, 83
Propagation of infection, 4
Prophylaxis, 85
field work, 87
hand-washing, 87
hospitalization, 87
kissing, 87
nasal irrigation, 85
quarantine, 86
community, 86
individual, 86
sneezing, 86
Provost, 3
Psychic disturbances, 76

R

References, 145
Reflexes, 68
Respiratory paralysis, 78, 80
Rissler, 3
Roger, 3

S

Scheel, 3
Serum of recovered cases, 38
Spinal fluid, 25
Spleen, 25
Strauss, 3
Strumpell, 2
Susceptibility, individual, 6
  age, 9
  family, 10
  physical type, 6, 8
  race, 7, 8
  sex, 6
Symptoms, 62
  ataxia, 64
  circum orbital puffiness, 63
  diarrhœa, 62
  fever, 62, 65, 69
  Kernig's sign, 64
  muscular twitching, 64
  pharyngeal inflammation, 62
  shrugging gesture, 63
  spine sign, 64
  stiff neck, 64
  stupor, 64, 76
  universal over-stimulation, 64
  vomiting, 62
Syphilis of the central nervous system, 65
Systemic phase, 41

T

Tonsils, 25

V

Virus, behavior toward chemical agents, 24
  physical agents, 23
  distribution of the tissues, 25
  methods of inoculation, 24
  nature of, 23
  portal of entry, 24
  of exit, 24
  viability, 20
Vomiting, 62
von Wiesner, 4

W

Wassermann reaction, 71
Wickman, 2
Winter epidemic, 19

Z

Zappert, 3